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Vol. I
TRANSCRIPT OF RECORD

(Pages 1 to 500)

Supreme Court of the United States

OCTOBER TERM, 1944

No. 50

THE DOW CHEMICAL COMPANY, PETITIONER,

vs.

HALLIBURTON OIL WELL CEMENTING COMPANY

No. 61

HALLIBURTON OIL WELL CEMENTING COMPANY,
PETITIONER,

vs.

THE DOW CHEMICAL COMPANY

ON WRITS OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT
OF APPEALS FOR THE SIXTH CIRCUIT

PETITIONS FOR CERTIORARI FILED { APRIL 6, 1944.
APRIL 17, 1944.

CERTIORARI GRANTED MAY 15, 1944.

Supreme Court of the United States

OCTOBER TERM, 1944

No. 50

THE DOW CHEMICAL COMPANY, a Corporation,
Petitioner,

vs.

HALLIBURTON OIL WELL CEMENTING COMPANY,
a Corporation,
Respondent.

TRANSCRIPT OF RECORD

On Petition for Writ of Certiorari to the United States
Circuit Court of Appeals for the Sixth Circuit

Volume I—Pages 1 to 500

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IN THE
UNITED STATES CIRCUIT COURT OF APPEALS
FOR THE SIXTH CIRCUIT

No.....


THE DOW CHEMICAL COMPANY, A CORPORATION,
Plaintiff-Appellant,

vs.

HALLIBURTON OIL WELL CEMENTING COMPANY,
A CORPORATION, *Defendant-Appellee.*

Appeal from the United States District Court for the
Eastern District of Michigan, Northern Division

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IN THE
United States District Court
EASTERN DISTRICT OF MICHIGAN
NORTHERN DIVISION

Pleadings and proceedings before the Honorable Arthur J. Tuttle, Judge of the United States District Court for the Eastern District of Michigan, in the following entitled cause:

No. 45

THE DOW CHEMICAL COMPANY, A CORPORATION,
Plaintiff.

vs.

HALLIBURTON OIL WELL CEMENTING COMPANY,
A CORPORATION,
Defendant.

Complaint

COMPLAINT

(Filed June 15, 1939)

(1) This is an action for infringement of United States Letters Patent.

(2) Jurisdiction is founded on the Patent Laws of the United States.

(3) Plaintiff is a corporation created and existing under the laws of the State of Michigan, and has a principal place of business at Midland, Michigan.

(4) Defendant is a corporation created and existing under the laws of the State of Delaware, having a principal place of business at Duncan, Okla., licensed to do business in the State of Michigan, and having a regular and established place of business at Mt. Pleasant, Isabella County, Michigan, within the Eastern District of Michigan, Northern Division, where, and elsewhere, it has committed the acts herein complained of.

(5) Letters Patent of the United States were duly and regularly issued to plaintiff as follows:

No. 1,877,504, on September 13, 1932, for "Treatment of Deep Wells," as assignee of John J. Grebe and Ross T. Sanford, both of Midland, Michigan.

(Here are listed three other patents that are not involved in the appeal, viz., Grebe 1,916,122, for Method of Treating Wells with Acid; Grebe and Stoesser 1,998,756, for Treatment of Deep Wells, and Chamberlain 2,024,718, for Treatment of Wells.)

Proffert of said Letters Patent, or duly certified copies thereof, is hereby made.

(6) Since the dates of issuance of said Letters Patent plaintiff has been and still is the owner thereof.

(7) Letters Patent No. 1,877,504, aforesaid, were held valid and infringed by the United States Circuit Court of Appeals for the Tenth Circuit, in the case of The Dow Chemical Company vs. Williams Brothers Well Treating Corporation. (81 Fed. 2d 495.)

Complaint

(8) Defendant for some time past, and within six years prior to the filing of this suit, has been and still is infringing said Letters Patent, and each of them, by practicing, in the Eastern District, Northern Division, of Michigan and elsewhere within the United States, the process of treating wells disclosed and claimed in said Letters Patent, and each of them, and particularly in Claims Nos. 1, 5, 7, 8 and 9 of Letters Patent No. 1,877,504; and will continue to do so unless enjoined by this court.

(9) Defendant has been notified of plaintiff's ownership of said Letters Patent, and each of them, and of its infringements thereof, and notwithstanding said notice defendant has continued said infringements.

Wherefore, plaintiff demands a preliminary and a final injunction against further infringement by defendant and those controlled by defendant, an accounting of profits and damages, and an assessment of costs against defendant.

Amended Answer of Defendant

AMENDED ANSWER OF DEFENDANT

(Filed Sept. 11, 1940)

Defendant, Halliburton Oil Well Cementing Company, answering the Complaint, filed on or about June 15, 1939, of the Dow Chemical Company, Plaintiff, says:

1. Answering Paragraph 1 of the Complaint, defendant admits that this is an action for infringement of Letters Patent.

2. Answering Paragraph 2 of the Complaint, defendant admits the jurisdiction of this Honorable Court.

3. Answering Paragraph 3 of the Complaint, defendant admits that plaintiff is a corporation created and existing under the laws of the State of Michigan and has a principal place of business at Midland, Michigan.

4. Answering Paragraph 4 of the Complaint, defendant admits that defendant is a corporation created and existing under the laws of the State of Delaware; that it has a principal place of business at Duncan, Oklahoma; and that it is licensed to do business in the State of Michigan and has a regular and established place of business at Mt. Pleasant, Isabella County, Michigan, within the Eastern District, Northern Division. Defendant denies that it has committed the acts complained of in the Complaint.

5. Answering Paragraph 5 of the Complaint, defendant admits that on September 13, 1932, United States Letters Patent No. 1,877,504 were issued to plaintiff, as assignee of John J. Grebe and Ross T. Sanford, for "Treatment of Deep Wells" but denies that said Letters Patent were duly and regularly issued.

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6. Answering Paragraph 6 of the Complaint, defendant admits that since the dates of issuance of the several patents in suit the plaintiff has been, and was at the date of the filing of this action, the owner of said patents.

7. Answering Paragraph 7 of the Complaint, defendant admits that Letters Patent No. 1,877,504 aforesaid,

Amended Answer of Defendant

were involved in litigation in the case of *The Dow Chemical Company vs. Williams Brothers Well Treating Corporation* in the United States Circuit Court of Appeals for the Tenth Circuit (81 F. (2d) 495), but asserts that there is no connection whatever between the defendant in that case and the defendant herein and asserts that defendant herein is not using the agents for inhibiting corrosion claimed to have been used by the Williams Brothers Well Treating Corporation, or any of the agents for inhibiting corrosion referred to and defined in the claims of Letters Patent 1,877,504, in suit. Defendant denies that all the claims of Letters Patent 1,877,504 aforesaid, were held valid by the United States Circuit Court of Appeals for the Tenth Circuit and asserts, particularly, that Claim 9 of said Letters Patent 1,877,504, one of the claims charged to be infringed herein, was not before the United States Circuit Court of Appeals for the Tenth Circuit in the case of *The Dow Chemical Company vs. Williams Brothers Well Treating Corporation*, *supra*.

8. Answering Paragraph 8 of the Complaint, defendant denies that it has at any time infringed, and denies that it is now infringing, the aforesaid Letters Patent, or either of them, by practicing in the Eastern District, Northern Division of Michigan, or elsewhere in the United States, processes embodying the alleged patented inventions, and particularly claims 1, 5, 7, 8 and 9 of Letters Patent 1,877,504, and defendant denies that it will infringe any of said Letters Patent unless enjoined by this court.

9. Answering Paragraph 9 of the Complaint, defendant denies that it has been notified of plaintiff's ownership of said Letters Patent, or any of them, and denies that it has been notified of the alleged infringement of any of said Letters Patent and defendant denies that, notwithstanding notice, it has committed any acts of infringement.

Further answering the Complaint:

10. Defendant avers that plaintiff has asserted, and is asserting in this action, a broad and dominating monopoly wholly unsupported by any invention made by the alleged

Amended Answer of Defendant

inventors of the Letters Patent in suit, and wholly unsupported by any invention disclosed by the patents in suit.

11. Defendant avers that it is not using any invention claimed, or even disclosed, by any of the Letters Patent in suit. On the contrary, defendant is utilizing methods developed or designed by others than the patentees in the patents in suit. Defendant is utilizing, among others, methods described and covered by the following Letters Patent of the United States issued to defendant as assignee:

No. 2,122,483, Paul L. Menaul, July 5, 1938, "Methods and Means for Acidizing Wells";

No. 2,149,617, Paul L. Menaul, March 7, 1939, "Methods and Apparatus for Handling Acidic Solutions."

12. Defendant avers upon information and belief that the Letters Patent in suit, and particularly the claims thereof herein charged to be infringed, and each of them were so restricted and limited in scope by the procedure in the Patent Office prior to the issuance of said Letters Patent that such claims, and each of them, if valid at all, are not entitled to a construction which will include or cover any device, composition of matter or process made, sold, used or practiced by defendant; wherefore, defendant denies infringement of any of the claims of said Letters Patent.

13. Defendant avers upon information and belief that the claims of the Letters Patent in suit herein charged to be infringed cover mere aggregations or old combinations of method steps and not new patentable methods and are, therefore, invalid under the law.

14. Defendant alleges upon information and belief that the claims of the Letters Patent in suit herein charged to be infringed distinguish over the prior art existing at the time of the alleged inventions only by the substitution of known equivalent steps in the methods of the prior art.

15. Defendant alleges upon information and belief that the patentees of Letters Patent 1,877,504 in suit surreptitiously and unjustly obtained the patent for things which are in fact the invention of W. A. Thomas of Sagi-

Amended Answer of Defendant

naw, Michigan, now of Mt. Pleasant, Michigan, who was using reasonable diligence in adapting and perfecting the same.

16. Defendant avers upon information and belief that the claims of Letters Patent 1,877,504, charged to be infringed by this defendant, are invalid and void and of no effect for the following reasons:

(a) That the methods described and claimed in each of said claims, respectively, or material and substantial parts thereof, were patented or described in printed publications prior to the alleged invention or discovery thereof by the patentees of the patent in suit, or more than two years prior to their application for Letters Patent therefor, as follows:

United States Letters Patent

Number	Patentee	Date of Issue
288,150	B. F. Aiken, Jr.	Nov. 6, 1883
372,154	A. Krause	Oct. 25, 1887
556,651	J. W. Van Dyke	March 17, 1896
556,669	Herman Frasch	March 17, 1896
670,577	G. L. Ball	March 26, 1901
856,644	C. E. Laverty	June 11, 1907
914,916	J. C. Beneker	March 9, 1909
1,194,542	N. H. Raymond	Aug. 15, 1916
1,221,735	A. F. Hoffman, et al	April 3, 1917
1,325,293	L. S. Hoon	Dec. 16, 1919
1,365,141	M. A. Adam	Jan. 11, 1921
1,382,337	G. C. Bellis	June 21, 1921
1,398,507	J. H. Gravell	Nov. 29, 1921
1,399,651	Adolph Pessi	Dec. 6, 1921
1,410,827	W. F. Muehl	March 28, 1922
1,421,706	R. Van A. Mills	July 4, 1922
1,428,085	J. H. Gravell	Sept. 5, 1922
1,433,579	Otto Vogel	Oct. 31, 1922
1,460,395	Otto Vogel	July 3, 1923
1,470,225	Harry N. Holmes	Oct. 9, 1923
1,476,747	F. H. Wolever	Dec. 11, 1923

Amended Answer of Defendant

Number	Patentee	Date of Issue
1,498,045	F. W. Lake	June 17, 1924
1,513,371	A. C. Campbell	Oct. 28, 1924
1,524,435	A. F. Hoffman, et al	Jan. 27, 1925
1,531,173	J. D. Brady	March 24, 1925
1,549,411	J. H. Gravell	Aug. 11, 1925
1,608,709	R. Van A. Mills	Nov. 30, 1926
1,608,869	Elvin Tilton	Nov. 30, 1926
1,615,121	M. E. Fyleman	Jan. 18, 1927
1,619,835	B. S. Summers	March 8, 1927
1,632,833	J. H. Gravell	June 21, 1927
1,635,500	H. E. Potts	July 12, 1927
1,678,775	J. H. Gravell	July 31, 1928
1,678,776	J. H. Gravell	July 31, 1928
1,713,653	J. H. Gravell	May 21, 1929
1,719,167	G. D. Chamberlain	July 2, 1929
1,719,650	G. D. Chamberlain	July 2, 1929
1,721,389	J. H. Gravell	July 16, 1929
1,723,923	J. G. Davidson	Aug. 6, 1929
1,729,097	I. H. Derby	Sept. 24, 1929
1,734,990	A. H. Ackerman	Nov. 12, 1929
1,736,282	Chas. Fischer, Jr.	Nov. 19, 1929
1,746,677	Fred H. Rhodes	Feb. 11, 1930
1,746,678	Fred H. Rhodes	Feb. 11, 1930
1,748,494	Paul I. Murrill	Feb. 25, 1930
1,750,651	James C. Vignos	March 18, 1930
1,756,311	W. L. Semon	April 29, 1930
1,757,829	Viktor Bertleff	May 6, 1930
1,766,902	M. M. Harrison	June 24, 1930
1,773,953	H. P. Corson, et al	Aug. 26, 1930
1,780,594	R. E. Lawrence	Nov. 4, 1930
1,780,595	R. E. Lawrence	Nov. 4, 1930
1,785,513	W. S. Calcott, et al	Dec. 16, 1930
1,789,805	F. D. Bürke	Jan. 20, 1931
1,796,839	J. H. Gravell, et al	March 17, 1931
1,804,078	M. W. Baden	May 5, 1931
1,805,052	L. B. Sebrell	May 12, 1931
1,806,499	Leo Ranney, et al	May 19, 1931

Amended Answer of Defendant

Number	Patentee	Date of Issue	
1,808,185	D. H. Tomkins	June	2, 1931
1,808,188	D. H. Tomkins	June	2, 1931
1,808,200	T. W. Bartram, et al	June	2, 1931
1,809,621	H. P. Corson	June	9, 1931
1,822,271	G. W. Coggeshall	Sept.	8, 1931
1,823,439	Melvin DeGroote	Sept.	15, 1931
1,823,440	Melvin DeGroote	Sept.	15, 1931
1,829,705	J. C. Walker	Oct.	27, 1931
1,843,376	Richard Stusser	Feb.	2, 1932
1,843,783	August Regal	Feb.	2, 1932
1,850,757	S. I. Levy	March	22, 1932
1,861,176	Melvin DeGroote	May	31, 1932
1,861,177	Melvin DeGroote	May	31, 1932
1,873,083	J. C. Walker	Aug.	23, 1932
1,873,084	J. C. Walker	Aug.	23, 1932
1,881,721	J. M. Leaper	Oct.	11, 1932
1,891,667	R. H. Carr	Dec.	20, 1932
1,892,205	Melvin DeGroote	Dec.	27, 1932
1,894,759	Melvin DeGroote	Jan.	17, 1933

BRITISH LETTERS PATENT

163,519 Martin E. Fyleman May 26, 1921

PRINTED PUBLICATIONS

- Bulletin 233 of U. S. Bureau of Mines (1925) entitled "Protection Against Corrosion in Oil & Gas Fields";
 Industrial and Engineering Chemistry, June 1928, Vol. 20, No. 6 pp. 582-587, article entitled "The Electrochemical Action of Inhibitors in the Acid Solution of Steel and Iron";
 Petroleum Development & Technology (1926) "Corrosion in an Oil Refinery" by H. F. Perkins, Port Arthur, Texas, pp. 560-570 and discussion 479-480.
 Corrosion—Causes and Prevention--1926, by Frank N. Sheller;

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Chemical and Metallurgical Engineering, Vol. 36, No. 9, September, 1929, pp. 539, et seq. "Inhibitors as a Means of Reducing Corrosion" by E. L. Chappell.

Bulletin of Bureau of Mines entitled "Water Problems in the Northern Part of the Cushing Field, Creek County, Oklahoma" by D. P. Wardell, et al., February, 1927;

Chemical and Metallurgical Engineering, July, 1927, Vol. 34, No. 7, pp. 421-424, articles entitled "Practical Application of Inhibitors in Pickling Operations" by Speller & Chappell, and "Removing Rust from System with Piping Acid" by Speller, et al;

Principles of Electrochemistry by Blum and Hogaboom (First Edition) (pages 64-67);

Bureau of Mines Technical Paper No. 15, (1913), entitled "An Electrolytic Method of Preventing Corrosion of Iron and Steel" by J. K. Clement and L. V. Walker

and also other patents and printed publications, the names, numbers, dates and authors of which are not at present known to defendant, but which when ascertained defendant prays leave to add hereto.

(b) The methods described and claimed in each of the claims of Letters Patent 1,877,504 in suit do not involve invention over the prior art cited in paragraph (a) hereof, but represent, at most, the exercise of mere skill in the art.

(c) The patentees of Letters Patent 1,877,504, in suit, were not the original and first inventors or discoverers of the things patented thereby, or of any material or substantial part thereof, but prior to the alleged invention thereof by the said patentees of said Letters Patent, the same were, if invention be involved therein, invented by or known to the patentees listed in paragraph (a) hereof, at the addresses given in the Letters Patent and applications involved, and by:

Muskegon Oil Corporation, Muskegon, Michigan;

Gulf Oil Corporation, Pittsburgh, Pennsylvania, and its subsidiaries;

Grasselli Chemical Company, Cleveland, Ohio;

Ohio Oil Company, Cleveland, Ohio;

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Solar Refining Company, Lima, Ohio; and
American Chemical Paint Company, Ambler, Pennsylvania,
Gulf Oil & Refining Company, Pittsburgh, Pennsylvania

and also by others not now known to defendant, but which when ascertained, defendant prays leave to add hereto.

(d) That prior to the alleged invention by the patentee in Letters Patent 1,877,504 in suit, or more than two years prior to the filing of the application for said Letters Patent, the alleged invention thereof had been in public use or on sale in the United States by:

Muskegon Oil Corporation, Muskegon, Michigan, at or near Muskegon, Michigan;
Gulf Oil Corporation, Pittsburgh, Pennsylvania and its subsidiaries, in or near Lee County, Kentucky; in or near Claiborne Parish, Louisiana; and in various places in Oklahoma;
Grasselli Chemical Company, Cleveland, Ohio, at East Chicago, or Grasselli, Indiana;
Ohio Oil Company, Cleveland, Ohio, at or near Lima, Ohio and Findlay, Ohio;
American Chemical Paint Company, Ambler, Pennsylvania, at Ambler, Pennsylvania;
Gulf Oil & Refining Company, Pittsburgh, Pennsylvania at Homer, Louisiana,

and by the patentees listed in paragraph (a) hereof, at the addresses given in their respective patents and applications therefor, and also by others not now known to defendant, but which when ascertained, defendant prays leave to add hereto.

(e) That Letters Patent 1,877,504 are invalid and void because granted by the Patent Office through inadvertence, accident or mistake. Defendant alleges that the Primary Examiner was interviewed during the pendency of the application which matured into Letters Patent 1,877,504, while the Assistant Examiner, who was an expert in the art, was away on his vacation. At this interview the Ex-

Amended Answer of Defendant

aminer was given to understand, intentionally or otherwise, that, contrary to the facts, the prior art did not disclose the use of hydrochloric acid for the treatment of oil wells. The Examiner informed counsel, in writing, of this understanding. Counsel did not correct the Examiner's mistaken views, but immediately paid the final fee and had the patent issued.

(f) That the invention or discovery purported to be covered by Letters Patent 1,877,504 alleged to have been the joint invention of John J. Grebe and Ross T. Sanford was in fact the sole invention of John J. Grebe only.

(g) That the invention or discovery purported to be covered by Letters Patent 1,877,504 alleged to have been the joint invention of John J. Grebe and Ross T. Sanford was in fact the sole invention of Ross T. Sanford only.

(h) That the invention or discovery purported to be covered by Letters Patent 1,877,504 alleged to have been the joint invention of John J. Grebe and Ross T. Sanford was in fact the joint invention of John J. Grebe, Ross T. Sanford and W. A. Thomas.

(i) That the invention or discovery purported to be covered by Letters Patent 1,877,504 alleged to have been the joint invention of John J. Grebe and Ross T. Sanford was in fact the joint invention of John J. Grebe and W. A. Thomas.

(j) That the invention or discovery purported to be covered by Letters Patent 1,877,504 alleged to have been the joint invention of John J. Grebe and Ross T. Sanford was in fact the joint invention of Ross T. Sanford and W. A. Thomas.

Wherefore defendant prays that said Letters Patent No. 1,877,504, be declared invalid and of no force or effect; that defendant be decreed to not infringe the aforesaid Letters Patent; that costs herein be taxed against the plaintiff; and that the Complaint herein be dismissed, and for such other and different relief as to the court may be just and equitable.

Stipulation Re Previous Litigation

COUNTERCLAIM

The Answer included a Counterclaim based on Gravel Patent 1,678,775, issued July 31, 1928, for storage and transportation of acid mixtures in steel drums, which counterclaim was dismissed and no appeal taken therefrom.

STIPULATION RE PREVIOUS LITIGATION

The following stipulation was entered into with respect to previous litigation on Grebe and Sanford Patent No. 1,877,504:

"1. That suit was brought by the Dow Chemical Company vs. Williams Brothers Well Treating Corporation, on or about the 24th day of April, 1934, for the alleged infringement of United States Patent to Grebe et al., No. 1,877,504.

"2. That said suit came on for trial in the United States District Court for the Northern District of Oklahoma, before the Honorable Judge F. E. Kennamer, during the month of September, 1934.

"3. That by final decree on or about January 15, 1935, the Bill of Complaint was dismissed.

"4. Plaintiff, The Dow Chemical Company, thereupon took an appeal to the United States Circuit Court of Appeals for the Tenth Circuit, which appeal was docketed as No. 1285.

Stipulation Re Previous Litigation

"5. That the decision of the Tenth Circuit Court of Appeals was as reported in 81 Fed. (2d) 495.

"6. That for the purposes of this stipulation, the transcript of testimony and the copies of exhibits printed in the transcript of record on appeal to said United States Circuit Court of Appeals, for the Tenth Circuit, entitled 'The Dow Chemical Company, Appellant, vs. Williams Brothers Well Treating Corporation, Appellee,' shall be considered as being true, complete and correct copies of such testimony and exhibits before the District Court, subject to correction of such copies of exhibits on comparison with originals thereof, should error appear.

"7. That if called and sworn to testify as witnesses herein, the following individuals,

L. C. Case

S. C. Kiser

Harry F. Wright

W. A. Hower

R. S. Knappen

R. L. Wright

who gave testimony in the aforesaid case of the Dow Chemical Company vs. Williams Brothers Well Treating Corporation, either on examination in open court or by deposition taken out of court, each would testify to the same facts as they testified to in the said former cause, subject to correction by any additional testimony of any of said individuals taken on behalf of either party hereto.

"8. That insofar as the same may be relevant to any issue herein, either party hereto may offer as evidence in this cause, any portion of the fact testimony of the above identified witnesses named in paragraph 7 hereof, or any portion or portions of any exhibit offered in the aforesaid Williams Brothers case, with the same force and effect as though such testimony had been taken or exhibits had been offered herein, subject to the right of the opposing party to object to any such offer on any ground that might be urged against it herein, if said witnesses had been sworn and examined, or such exhibit had been offered in this cause, whether or not such testimony or exhibit was objected to at the time it was taken or offered in said former cause."

Statement of Testimony and Proceedings in District Court

**NARRATIVE STATEMENT OF TESTIMONY AND
PROCEEDINGS IN DISTRICT COURT**

Following is a statement of the testimony and proceedings in the District Court, portions of which are in narrative form and other portions in question and answer form.

The following exhibits were marked and offered:
Copy of Grebe-Sanford Patent 1,877,504 as PX-1.
Copy of Grebe Patent 1,916,122 as PX-2.
Copy of Grebe-Stoesser Patent 1,998,756 as PX-3.
Copy of Chamberlain Patent 2,024,718 as PX-4.
Copy of Gravell Patent 1,678,775 as DX-5.

JAMES O. LEWIS,

a witness called by plaintiff, testified as follows:

DIRECT EXAMINATION

I live in Houston, Texas, and am a consulting petroleum engineer. I got my technical training at the University of Stanford where I graduated as a geologist, prepared for petroleum geology. After graduation I spent two years with the Associated Oil Company in California as a field geologist, and after that I spent three years employed by

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Harry R. Johnson of Los Angeles and Robert B. Moran then of San Francisco. My work was partly field geology, concerned with oil, except for one special job of a few months, and also some engineering problems in the production and valuation of oil, and the drainage of oil underground.

I then went with the United States Bureau of Mines in the fall of 1914, and was with them for six years.

My first position was that of oil and gas inspector, doing joint investigation work for the United States Bureau of Mines, and the Indian agency of Muskogee, Oklahoma. I worked jointly with the Indian office and the United States Bureau of Mines investigating the causes and remedies for the waste of oil and gas which were then taking place in Oklahoma. I was in that work for one year, and I was then employed by the Bureau of Mines directly for two years in investigative work, mainly concerned with methods for increasing the recovery of oil; methods for estimating the future production of oil and gas, and other methods for conserving oil and gas. During that time I wrote three technical bulletins and papers for the Bureau of Mines.

In 1918 I was placed in charge of the Bureau of Mines Petroleum Experimental Station at Bartlesville, Oklahoma. The station was just being founded. It was the first petroleum station of the Bureau of Mines. Also during that year we had outside work—I mean in addition to the organization of the station, in helium problems, which were then active, working out methods for the Bureau of Internal Revenue, for estimating the reserves of oil and gas, to be used in connection with depletion allowance in income taxes, and other activities in Oklahoma, and elsewhere in the United States dealing with conservation.

During 1919 and 1920 I was chief petroleum technologist of the Bureau of Mines, that is, I was in charge of all petroleum work of the Bureau of Mines during those two years, and was located in Washington, D. C. I left the Bureau of Mines in 1920, and went to Marietta, Ohio, and became a member of the firm of Smith & Dunn. The firm

James O. Lewis

of Smith & Dunn had a patented process for increasing the recovery of oil by injecting air or gas into depleted oil fields.

In the fall of 1920 I moved to Tulsa, Oklahoma, with Mr. Dunn, and we formed the firm of Dunn & Lewis, which was in business together until about a year ago. Mr. Dunn was the inventor of this process of increasing the recovery of oil, also other processes for cleaning out wells, and helping recovery of oil and gas. Our business there was a general petroleum engineering business but specializing in methods for recovering oil and gas. We had a number of properties which we took over, some under management, some under ownership, to which we applied this process of Mr. Dunn's and other processes. We also had consulting work from larger companies, advising on various matters, namely, South Penn, Central, New Jersey, Tidewater, Petroleum Gas Company, and some other gas companies. During these years I have done a great deal of consulting work on valuation, estimations of oil and gas and various problems relating to the production and recovery of oil and gas. Mostly my work has been on the conditions which exist underground, and the methods for bettering the recovery of oil and gas therefrom.

About a year ago, I dissolved partnership with Mr. Dunn and have been located in Houston, Texas, as a consulting engineer in such problems. At present I am engaged in a joint problem for a group of companies in California, one of the largest fields there—the Kettleman North Dome Field—working out problems connected with what is known as the cycling of gas from the very deep sand which should be used by these joint operations. These companies include most of the larger operating companies in California. I also have similar problems on increasing the recovery of oil in some properties of an English company in Trinidad which company happens to be the largest producer of oil of any British-owned colony.

Q. Now, I wish you would tell the court, please, what were the actual conditions, we will say, before acidizing

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became popular, as to the percentage of the oil in the ground which was actually gotten out. Tell them both as to limestone and sandstone. A. It has always been rather a difficult question to estimate how much oil actually is in the ground, and hard to give general answers in magnitude and figures. Also, there have been changes in the character of fields which have been found at different times and in the methods of producing that oil and gas. In the earlier part of the industry most of the oil was produced from what is known as tight sands—they call them sand but really they are sandstones, originally laid down as loose sands but in the course of geological changes have been cemented and the permeability had become quite low. The oil and gas found in them was quite difficult to obtain. While that character of field was being produced, the recovery was obviously quite low. In 1917 I estimated the average recovery was between 10% and 20%. That is, from 80% to 90% of the oil was being left underground. That was probably a little low. Probably they were getting a little more than that, as we since have found out. It wasn't very far from the real order of magnitude. Since that time the character of fields has been different. We have been finding more deep fields, more oil has come out from sands, more permeable, and have made advancements in recovery. So the efficiency of recovery is better, considerably. Probably at the present time the recovery is of the order around 40%.

Now, as to the limestones, there is much greater variability in the question of limestones, and consequently the percentage of extractable oil—probably on the average, the percentage of extractable oil is somewhat higher in limestones than it has been in sandstones. That is, instead of it being of the order 20% in the tight sands, so-called in limestone, it is more likely to be 30%, possibly a little greater. That was up prior to the extensive use of acid.

Q. Now, how long has it been since this increasing of the production of wells was recognized as a real problem to be met by the industry? A. Well, it was almost recog-

nized from the beginning to some extent. That is, the first producers found that the wells would come in in large volumes, comparatively large volumes, and then quickly the amount of oil which the well would produce would shrink, so they were almost immediately confronted with the fact of a diminished return following the completion of the well, and became interested in methods which would tend to increase the daily production.

They did not so quickly become conscious of the fact that after the well had ceased producing, they had not exhausted all the oil, but it was not many years before they commenced to see that they were not getting all the oil, though it took quite a long while for them to get a means of estimating quantitatively how much that was. They knew they were losing some of the oil, and it must be a considerable quantity. The original first Drake well, the first petroleum well in this country, was in 1859.

Q. And how long was it after that before they had some record evidence of efforts to increase the productivity of the wells? A. Well, from the standpoint of merely increasing the daily production of wells, with no respect to whether or not the ultimate production was increased, there are records almost immediately of going in and cleaning out wells. They recognized that the formations would cave off the walls of the hole and fill up the hole. They would go in and clean that out.

Also they had devices for lifting the oil by various pumping means. Gas lifts were first applied very early in the industry, at least, tried out, and as soon as a well ceased to flow under its natural pressure, there were many expediences applied to increase its daily production.

Then, in 1865, the first method which went further than that, which went more than merely cleaning out the hole itself and bettering the lifting means, was applied by Colonel Roberts, who was the colonel in the U. S. Army during the Civil War who invented the torpedo, as he called it. That is, his method was to put in a charge of nitroglycerine into the well, explode it there, which would enlarge the hole and crack the formations back from the hole some distance, just

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how far he did not know, and also tend to clean off the walls of the hole of obstructing materials.

Mr. Lyon:

Your Honor please, it seems to me that from the witness' last statement, something that happened in the Civil War, judging by the fact he said he was a graduate of Stamford University, and Stamford was not founded until the 90's, this witness is not testifying to anything of his own knowledge.

The Court:

I take it this is the recorded history, like who discovered the steamboat.

Mr. Lyon:

It seems to me this is not the proper way to prove it; to prove the history, I mean, by an oral witness.

The Court:

Well, if it is history, it cannot affect the decision of the lawsuit really. It is just background, and I don't want him to use up very much of my time or their money in order to prove this. I take it that if he isn't corrected by some of the people connected with your side he is correct about it. I take this as background and history of an art that goes way back beyond anything I will use in deciding the lawsuit, and yet it is interesting.

Mr. Wiles:

Of course, we want to show that this has been a problem ever since the industry started.

The Court:

I will let him go ahead, and he will come down to something more recent.

By Mr. Wiles, continuing:

Q. This process that you have just mentioned as shooting wells, that continued to a considerable extent up to rather recent times, did it not? **A.** Yes, it has continued right up to the present time, and is still in use. Shooting is not effective in all formations, either in all sandstones or all limestones, but it has favorably affected production, above the rate, and the ultimate recovery in many limestone fields.

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Q. Is there a rather localized effect, close to the well, or can it be extended for a considerable distance? A. We know from measurements of the size of the hole after shooting that it has not enlarged the hole very greatly, that is where the hole was originally six to eight inches in diameter, it may enlarge it to some twelve inches, something like twelve inches, and occasionally eighteen inches, but it also cracks the rock, but how far it cracks it I do not know, and I have never heard any figures which would prove how far back it cracks it.

The Court:

Is there anything about whether or not the fact it might make a well to it,—like where you applied it to the stump out here or a hole in the ground? It doesn't take it with this rock, as I understand; it tends to split it rather than throw pieces back? A. It can't throw the rock back because there is no place for it to go, and it can't blow up because you have the formations holding it down, unless you put in an overcharge, and if you put in an overcharge, of course, it might do damage to the top of the well if the well was shallow. The figures I gave in 1917 were made in view of shooting the wells and the processes of increasing recovery except the use of injected air or gas, and except the use of flooding. In other words, they were for methods used prior to those two processes.

The Court:

Shooting them would increase it, it helped? A. Oh, yes, very greatly.

The Court:

What other method did you say besides the shooting of them? A. They used various methods for cleaning out the hole itself, and at a later date in 1869 they applied what is known, what they then called a gas pump which was a vacuum pump. And, the principle on which they operated was to remove the atmospheric pressure and permit the gases in the rock to expand an additional few pounds.

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The Court:

You mean pump the air out and make a vacuum? A. There wasn't any here in the underground, but they made the casing head tight, and connected the pipe to the casing head and applied this suction pump to it. The vacuum has been used up to the present time.

The Court:

You made your vacuum above. Wouldn't that tend to make that oil come up? A. It would tend to make the oil flow more freely and expand the gas which was in the rock. You see, your oil is flowed from the pores of your producing formation in the wells.

The Court (Interposing):

Held under pressure? A. Originally, your oil with the gas in solution is under considerable pressure, and that gas expands and pushes the oil with it to the well from which it is lifted to the surface by either natural flow or various mechanical means. In time your natural gas forces become depleted and become ineffective until finally if you don't do something to replace these natural forces you wouldn't have enough force to force your remaining oil to the well. At that stage these old operators would go and put on their vacuum pumps, or gas pumps they then called them, and by removing atmospheric pressure it was the same as if they put into the sand another twelve or thirteen pounds of pressure, because it allowed the gas to expand against that much less pressure, and your gas in expanding had atmospheric pressure, which is about 14.7 pounds at sea level, and by using a gas pump you could remove that pressure from it and allow the gas to expand that additional amount.

Mr. Wiles:

Q. To get some idea of how important this vacuum is in per cent, proportion, what is the underground pressure likely to be like, say, at several thousand feet? A. The underground pressure, that is the original underground pressure has an extremely wide range. It is usually in approximate proportion to the depth, and usually it is

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about 43 pounds pressure for each 100 feet of depth. That is an approximation which isn't true, but is generally true, so that the first wells, which were shallow, had original pressures of maybe less than one hundred pounds. In recent years where they have been drilling to great depths wells of ten thousand feet or more they have pressures of five or even six thousand, even seven thousand pounds initial pressure. So that pressure varies with those great ranges in accordance with the depth more than any other factor.

Q. In view of those figures, the 15 pounds difference that you can make with a vacuum would be rather insignificant, would it not? A. The amount of push which the vacuum or gas pump would make was not large and was negligible in the deeper sands. In some of the shallower sands it was rather important, but it could not be a highly effective process.

Q. Now, there is a process known as re-pressuring, is there not? A. Yes. The word "re-pressuring," I might say, is used in a good many different senses, but in the sense I believe you mean it is the injection of either compressed air or compressed gas into a depleted field. That is, instead of what you might say putting a pull on the sand by a gas or vacuum pump you can put a push on it by taking air or gas and compressing it in a compressor, and injecting it into one well and allowing it to flow through the sand into producing wells around it. And, of course, the pressure which you can generate in that manner is unlimited, whereas the additional pressure which you release from the sand by a vacuum pump was distinctly limited.

The Court:

I suppose you have tried to apply your air to some low place in the pool and get it out at a higher place?

A. There have been various theories and the theories have been applied very largely in accordance with local conditions. In some pools it seems to be better to distribute your output and input wells, producing wells as they call

them, in some structure which seems to be best to put all your gas in the high part, and force your oil down so that the oil will flow with gravity in addition to the aid of your pressure. In other cases they have them put it in at the edge of the pool and forced it up. Generally the best practice, at least a practice which the engineers seem to agree upon, is to put it in the high part of the structure if there is a pronounced depth to the sands.

In limestone formations the repressuring systems have not been markedly successful. It has been tried in a good many cases, and it is very seldom successful. The reason seems to be that the pores in your limestones are of a different origin, and have a different nature than sands, and your air or gas will, of course, take the lines of least resistance, and usually in limestone there are channels of resistance which are so much less than the body of the limestone that your air and gas would pass through, doing very little good.

For example, in the Trenton pool, an application I know of, they injected the air into the formation, and instead of that air showing itself about the nearest wells, it followed a line across the field and appeared in wells a distance of a mile away, apparently having followed a fracture zone. That seems to be the most logical explanation. The exact conditions we were unable to get any proof of.

Q. There are methods also where you add water, are there not? A. Yes, instead of putting in a gas, you can put in a liquid, and practically the only liquid which would be commercially feasible was water. I do not know of any case where it has been very effective.

Also, prior to 1931 we used various reamers which would go into the ground and enlarge the drill hole from its six or eight inches to so much as three feet in diameter, that is, ream it out mechanically. That was used to a limited extent, and did some good. It increased production some, but not to a highly important degree.

There were also methods for removing the paraffin which would accumulate in the pores; that is, as the well

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gets old, certain oils have paraffin waxes in them, which would separate out; and this paraffin would accumulate in the pores of the sands immediately around the hole and clog it up. There are various treatments for that, such as steaming it out, circulating hot oil, putting in chemicals, electrical heaters, which would remove the obstruction. That also applied to old holes where mineral matter had been deposited in the pores of the sands and clogged it up. To remove that they have put in light shots, which would crack it off.

Q. As far as wells in limestone are concerned, aside from the shooting process which came in, as you said, in 1865, was there any serious method developed that went into practical use to any extent? A. Well, up to acidizing, I don't recollect any methods which came into general use and were of any importance.

Q. When did proration come in? A. The first proration was generally effected about 1926 in Oklahoma and created a special reason for obtaining maximum daily production from a well. The formulas for prorating the production of wells were based upon what they call the potential of the well, either wholly or largely. That is, if the well had a capacity to produce, say, one thousand barrels if it were allowed to produce its full quantity, it would be given a higher allowable than a well which, say, could only produce five hundred barrels a day. So the incentive on the part of the operator was to put his wells in condition so that they would make the best showing when these potential tests were made.

Q. Now during this same time, do you know of processes for increasing the production of wells which were tried experimentally and abandoned? A. Oh, I used to hear of various methods and ideas of increasing recovery. Of course, it is my business—

Mr. Lyon (interposing):

Your Honor please, I don't think we ought, if this evidence is going to be used, to receive evidence about what this witness heard, which he characterized as abandoned or experimental.

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The Court:

If it is something you dispute, I would adhere to that, I think.

Q. Name the methods you know about or which became known in the industry so that, as an expert, you would know about it? A. One of them I know of personally was the idea of heating up the rock by either forcing in steam through the producing formation or hot water or some other fluid which would be a conveyor of heat into the rock, the theory being that you thus reduce the viscosity of oil and also you generate gases from the gasoline which was a part of the oil in the rock. The idea was to pump the hot water in through the wells right into the formation.

The Court:

It would get cold before it could get down there. A. That is exactly what happened. All of those methods, however, were tried, and personally I made many, many calculations on them. They all failed because the mass of heat in the rock itself was so great that it was not feasible. One plant they tried it and got a good increase, but they found that putting steam into the rock, they found it took all the additional oil they recovered and all they produced before to raise steam to heat up the rock.

The Court:

What is the temperature down there a couple of miles? A. When you get down a couple of miles it is likely to be around 250 degrees Fahrenheit. One hundred feet down it will generally be the average surface temperature, which in this (Michigan) climate, if you average the year round temperature is about 45. That is my guess.

The Court:

You get down a mile and it would be how much? A. The general rule is that your temperature increases one degree Fahrenheit for every 70 feet of depth, and you start at the surface. That is, your average yearly atmospheric temperature becomes the temperature of the rock at about 50 to 100 feet below the ground, and your heat gradient, as they call it, begins from that point. Down south in

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Texas the average surface temperature is around 75 and up here I suppose it is about 45, so you start with a temperature which is lower, but your increase is about the same.
The Court:

One degree for each seventy feet? A. About one degree for each seventy feet of depth. You have so much pressure your water couldn't boil. You get away above 212 degrees, only your boiling point has the factors of temperature and pressure.

The Court:

You mean you can't get steam down in there? Can you? A. In the shallow oil well they can insulate the tubing carefully, and get down there and insulate the rock. What happens is the steam gets in the rock, then it condenses, then it cools off, so all you are doing is increasing the cycle of water. You start with the steam at the surface of the earth and force it right down through the tubing of the well into the sand. It never has been tried on deep wells—only shallow wells. It hasn't been successful. It isn't practical.

Another method, to continue my answer to your question, is to mine the oil. That is, sink shafts down to the sand and drive tunnels along the sand and let the oil drain out. I have seen some of those shafts and tunnels. It is feasible at a price but it costs so much that it wouldn't be commercially feasible at prices we have had in recent years.

The Court:

I don't get the idea of how you would tunnel it. A. You would tunnel it as you would in a coal mine—sink a shaft and drive drifts. It has been done for years.

The Court:

Drive it out sideways? A. Drive it out sideways. There is considerable danger in it but they have means of overcoming that danger.

The Court:

How deep do they drive? A. They can go to as great a depth as they could in ordinary mining operations.

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The Court:

Well, what is that? A. I don't know as there is any limit. The only limit is the temperatures they reach, and the cost. They have mines in this state over 6000 feet deep. This mining of oil was actually carried on commercially in France and Germany, where the price of oil was greater. In this country it is not feasible at present prices—purely a matter of cost.

The Court:

Then it goes out laterally? A. Then it goes out laterally, and they elevate it.

By Mr. Wiles:

Q. Now, taking the time from, oh say, 1910 or so, when the automobile began to greatly increase gasoline demand, what was the belief of the industry and of the government as to the future of the oil supply? A. The government and the industry generally went through a period of apprehensive shortage that commenced during the World War and continued for some years thereafter. That is, at that time they became conscious of the great need for oil and also of the fact that our oil fields were limited and sooner or later would exhaust. At that time there was a feeling that the period of exhaustion was quite close, was quite imminent. It wasn't until the late twenties that that apprehension was relieved, and they came to the conclusion generally we had more oil than we had originally thought.

Q. You have reserves in sight for many more years now than you had, say, in 1919? A. Yes, I believe we have.

Mr. Wiles:

I have here a Bureau of Mines Bulletin No. 177, published in 1919, and want to quote just one sentence, and I ask you whether this is a fair statement of the general attitude of the trade and government?

"At present the country is facing a serious shortage of petroleum. By way of preparing for the best way to meet this emergency, the Bureau of Mines has been carrying on technical investigations in the petroleum industry for several years." A. I believe that represents the majority of the opinion at the time.

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Q. I hand you Bulletin 148 of the Bureau published in 1917 (PX-7). Is that your work? A. Yes, I wrote this while I was with the Bureau of Mines.

Mr. Wiles (reading from bulletin at page 7):

"In its efforts to reduce waste, and increase efficiency in oil production, the Bureau of Mines is investigating methods of increasing the recovery from the underground sources of supply, which are the foundation of the petroleum industry and the many allied industries wholly or partly dependent on it. In the face of a demand that is increasing faster than the production and that, in the consensus of opinions of well-informed authorities, is soon likely to outstrip the productive capacity, it is well to consider whether it is not possible to extract more oil from the known sources of supply. It is universally acknowledged that by the usual production methods much oil is left underground, the general opinion being that at least 50 per cent of the oil in a field remains unrecovered when the field is abandoned as exhausted. From the writer's own investigations he believes the average recovery is even less, and if any considerable portion of this oil being left underground could be made available it would have a tremendously favorable influence on the petroleum industry and all the industries dependent on it.

"In this publication are considered the principles involved in increasing recovery and methods of extracting more oil from the oil-bearing formations than by the usual ways of producing. These methods are: The use of gas or vacuum pumps, forcing compressed air or gas through the oil-bearing formations, displacing the oil by water, and better utilization of the natural pressures in the oil-bearing formations. Especial attention is being given to a process—commonly known as the Smith-Dunn—for forcing compressed air through oil-bearing formations because it is believed to hold most promise for the future.

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"That much of the oil in a field is never recovered is well known, but how large a proportion is left underground

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and the possibility of increasing the recovery cannot be fully realized until one clearly understands that the exhaustion of an oil well is due more to the exhaustion of the natural gas, which is the principal agent in driving the oil into the well, than to the exhaustion of the oil itself.

"Facts presented in this bulletin go to show that the capacities of the oil sands in the various fields of the United States are five to ten times greater than the quantities of oil commonly extracted from them. If it could be fully established, as seems most probable, that the pores of the oil-bearing sands were completely filled with oil at the time the fields were first developed, then 80 to 90% of the oil is left underground when the wells are abandoned. Although the evidence at hand does not permit positive statements that this proportion is being left underground, there is abundant evidence that much oil capable of being recovered remains in the sands. Complete extraction is not to be hoped for, yet there is no reason to conclude that the maximum possible recovery has been reached when the natural forces have been exhausted, and, furthermore, it has been demonstrated that it is practicable to get more oil from the sands by the processes described in this report."

(The bulletin was offered and received as PX-7.)

The Court:

Is there any reference in this book to the acid?

Mr. Wiles:

No. This was published in 1917.

The Court:

Didn't you know about the Frasch patent? A. No, I hadn't heard of it. During all this period up to, say, 1932 acidizing of oil wells was not one of the things that was known and used generally all through the trade.

By Mr. Wiles:

Q. When was it that you first heard of acidizing as a practical proposition? A. Well, I had heard of it—in fact, witnessed a test as early as 1918 on oil producing sandstone to knock off the crust, and again in 1922, something like that, for the same purpose. The first I heard

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of acidizing on limestone formations was,—it must have been about 1932 or 1933. I can't remember the exact date. I first learned about the Frasch patent in connection with this case, within the last month.

Q. Within your experience now, how was acidizing received about when it was brought out in 1932? A. Well, it was received unusually rapidly for a new art in the industry. My experience at the Bureau of Mines where our principal function was to find and apply and introduce new methods led us to believe there was usually from five to ten years' inertia to overcome in introducing a new idea to the industry, and this was adopted much quicker than any other new idea within my experience.

Q. How soon was it,—how extensively did it become used in wells in limestone? A. Well, within a very,—only a matter of months, reports came in from almost every part of the United States where they had limestone fields. I think within two years I don't believe there was an area in which limestone production was important that I hadn't had reports that it had been used there.

The Court:

Well, we generally find seventeen years after a patent is granted the public gets the thing. What explanation have you got that that patent of 1896 didn't grow any fruit? Aren't you satisfied you could use, without any inhibitor, an acid to better advantage than you could blast or steam and these other things you have been telling me about? A. Well, it has been proved by experience that acidation is better than those other processes.

The Court:

Even if you didn't have the inhibitor? A. Well, I couldn't say as to that. Of course, the only thing I can say is that probably the early users of acid must have encountered so much trouble from it that they were discouraged, and these methods which were all coating pipe would not be such as would be practical in oil wells.

The Court:

They couldn't have tried very hard or encountered

much difficulty on the other hand of the government would have found out about it. Here is the patent hand of the government. The government has so many hands, they don't find what they have got in their pockets, but here is the Patent Office down there with this patent right on file in there, and you are right over in another branch of the government in the same city telling all these ways, and there is a better way than any of those you were describing right there, even if you did not have an inhibitor, I take it. Maybe I am wrong about it. A. I couldn't say as to that, whether the raw acid might do it or not.

The Court:

Have you got any of that history about that? Did you ever, you think, run into difficulty? I take it you are just theorizing about it? A. That is purely surmise. I have no history.

The Court:

Isn't there any available history about what that chap did with his patent, or what they did out in the oil fields?

A. If there is I don't know about it. I haven't made any search for it.

The Court:

Do you know, was he an oil man? A. One of them, in fact both of them, were in the oil business.

I recall this Frasch patent. There is a possibility that the acid might eat around the packer.

By Mr. Wiles:

Now, my view about this is this: Frasch puts in his patent, and he was a great man and everybody looked up to him with the greatest respect, and he says, "You can't put raw acid down there or you will spoil your pipe. Therefore, you must pull your pipe, put down a rubber covered pipe, and then introduce it, and then take out the rubber covered pipe and put down your pump pipe again." Now, considering the expense of bringing this special pipe in adequate quantity, and the assembling and disassembling you have to go through, do you think such a process would be acceptable to the trade at any time?

Mr. Lyon:

I object to that as too speculative, Your Honor. The witness hasn't qualified.

The Court:

Overruled. I have invited the question, I guess. I will let him develop it. A. I don't know as to what they knew back there in '96 or what they had, but I think it would be very difficult even under present knowledge to work out a system which would fully protect the pipe in that manner and prevent corrosion.

The Court:

How much is a mile of pipe worth? A. Well, it depends on the size. Tubing, ordinary two inch tubing generally costs about 25 to 35 cents a foot, according to the quality and weight of it. A mile of pipe would cost say \$1500, I should say off-hand.

The Court:

How long will it take that acid to eat through. A. I was going to add, if they keep that acid in any length of time it would be very difficult to get any protective which could be taken apart and put together again that wouldn't allow the acid at least to get into the seams.

The Court:

If you don't put the protective in there, how long would it take to eat through that? A. Oh, I don't know.

The Court:

Give me some idea? A. Well, I haven't gone into that.

The Court:

Days or weeks or hours or years or what? A. Well, I would say—I would have to more or less guess at it—I would say twenty-four hours, if the acid was left in the tubing, it would very likely eat through the walls.

The Court:

There may be some chap who had a poor well, a good sport like most of them have to be to put money down in the ground, who tried it out to see what would happen. A. They may have tried it. I don't know.

By Mr. Wiles:

Q. Now, can you tell us approximately the proportion of the oil production that comes out of limestone? A. Well, that is very difficult to get any precise estimates on and I haven't a precise estimate. All I can give you is the order of magnitude, and I would say it is about twenty-five per cent of the present daily production which is from limestone formations.

The Court:

Is this acid any good in sandstone? A. It has had, under special conditions, beneficial effects in some sandstone, where the sand contains a certain amount of carbonates, and in such case the acid may eat out this carbonate content and enlarge the pores and in that way increase the permeation.

The Court:

Has there been any other kind of acid they use for different kinds? A. Yes, they have other acids. They have proposed to use hydrofluoric acid which would eat the sand itself, but so far as I know that has not been satisfactory. It has not been practical. And they have mud acids which will eat a certain content of the mud which sometimes clogs the pores of the hole and which seems to be beneficial quite often.

By Mr. Wiles:

Q. Can you give us a rough idea of the price range of mid-continent crude for the period preceding 1932? Start with the Cushing pool in 1915 when prices were way down. A. I couldn't give you the exact figures. About all I could give would be some approximation. Prior to the Cushing pool the price ranged from a low of about 50 cents up to a little over \$1.00. During the Cushing pool the price went down to a point where they were not quoted. Oil was sold at the Cushing pool at a net of 10 cents a barrel. That was sold in the tank, and when you took away the tank cost, the oil itself sold for about 10 cents.

Then in 1916 it commenced to go up again, and about 1917 it reached over \$1.00. During the World War it was

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artificially held down to I think \$2.25. Then after the War it reached an all time high of \$3.50 in 1920, I believe.

In 1921 the oil price took a plunge along with other commodity prices and it went down to \$1.00 in the latter part of 1921 or 1922. Then it wavered back and forth reaching a high of about \$2.00 and went down again about 1925, and in 1926 36-gravity oil went up to \$1.86, I believe.

From 1926 to 1930 most of the time it was between \$1.00 and \$1.50 and it averaged about \$1.25. In the latter part of 1929 or 1930 it started to go down again, and in 1931, on account of the flood of oil from the East Texas pool and also the depression, it went very low. In 1932, due to better control of production it went up again. In 1933 proration broke down and it went very low. Since that time, it has averaged about \$1.00 or \$1.10.

CROSS EXAMINATION

I was with the Bureau of Mines from the fall of 1914 to the fall of 1920, six years altogether. As to whether or not during that period there was any knowledge in the Bureau of Mines of the use of hydrochloric acid in an oil well to react on the formation, all I can say is that I do not remember of its having been brought to my attention. However, there could have been knowledge of it on the part of some of the individuals in the organization. I know a man by the name of Rollin Van Auken Mills. He was connected with the Bureau of Mines during the last two or three years that I was there. He was a petroleum engineer, and his field of work was research on the treatment of wells and oil recovery. I think his principal problem was on the paraffin troubles. He worked under my general direction.

I have seen a bulletin, serial number 2550, dated December, 1923, entitled "Reports of Investigations, Department of the Interior, Bureau of Mines, Subject, The Paraffin Problem In Oil Wells," by R. Van A. Mills. It was prepared after I left the Bureau of Mines, but I read it

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afterwards, and I have read it recently. The work covered by it was started before I left the Bureau of Mines, under my general direction.

By Mr. Lyon:

Q. Well, now, this bulletin on page 9 has a paragraph entitled "Hydrochloric acid," and the text starts, "The Bureau of Mines has experimented with the use of hydrochloric acid," and so forth. Do you have any knowledge of the work that is referred to there? A. Well, I knew some of the work that he did before I left the Bureau of Mines; I know he had tried various chemicals in wells.

With reference to the patent issued to Mr. Mills No. 1,421,706, dated July 4, 1922, on an application filed October 15, 1918, I knew that he was filing for several patents, but I did not know just what they covered. He was connected with the Bureau of Mines on October 15, 1918.

Q. (By Mr. Lyon) This patent or patent application was dedicated to the public by Mr. Mills under the Act of March 3, 1883, as noted on the patent. Was that at your direction as head of the department? A. No, it wouldn't be under my direction, because I wouldn't have anything to do with the control of policies which refer to patents. I believe it was the practice of the members of the staff of the Bureau of Mines, while I was in charge, in filing patent applications to dedicate their use to the public under the Act of March 3, 1883.

Q. Now, this patent, on page 2, line 18, refers to the acid treatment of wells. Do you know what that refers to? A. I wouldn't know without reading the patent itself to see. There are two ways in which acid has been used in wells. One was the one I described yesterday as having witnessed in 1918 where it was used to remove the incrustations of mineral matter and mineral matter which had been deposited in the pores of sand. The other is to be used only in limestone wells, and I don't know what that refers to.

Q. Now, did you have knowledge of both of those methods while you were with the Bureau of Mines? A. The

only one that came to my attention while I was with the Bureau of Mines was the one for removing mineral incrustations in the sandstone wells.

Q. What is the difference in the action of the hydrochloric acid after you pump it down the well and force it into the formation whether the formation is sandstone or limestone? A. Well, only the chemical action depends on the materials in the well on which the acid acts. If there is any lime in the sandstone well, the reactions would be the same as if it was only limestone formation. That is, for that part of the reaction. Your reaction may also take place with other mineral matters in the sandstone well, which possibly might not be present in a limestone well.

Q. Then is there any sure distinction between these two methods that you have referred to or do they overlap and intermingle? A. I wouldn't say—of course, it is a matter of the structure of the reservoir rock. In one case the whole reservoir rock is soluble in acid, or mostly soluble in acid, and in the other you have a structure of insoluble material with a filling of acid soluble material or at least partly acid soluble material.

Q. Well, in either case the method is the same in the sense that you perform the same physical operations in introducing acid into the well and causing it to penetrate the formation, and the only difference is that the effect of the acid will vary with different formations; is that correct?

A. Well, speaking broadly, I think that is correct.

Q. Now, as I understand you, even today the results of acidizing a well are not uniform. Some wells you obtain beneficial results and others you do not, is that correct? A. That is the general report, yes.

Q. And particularly true on old wells, is it not? In some old wells you can increase the production by acidizing them; others you cannot? A. It is variable, yes.

Q. It is also true on new wells. In other words, you may acidize the new well and obtain no beneficial results from the operation, is that not correct? A. That is true, yes.

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The bulletin, Serial No. 2550, above referred to, was thereupon marked and offered as DX-8.

By Mr. Lyon:

Q. In your testimony, Mr. Lewis, yesterday you were asked: "Q. When was it that you first heard of acidizing as a practical proposition? A. Well, I had heard of it, in fact witnessed a test as early as 1918 on oil producing sandstone to knock off the crust, and again in 1922, something like that, for the same purpose. The first I heard of acidizing a limestone formation was, it must have been about 1932 or 1933, I cannot remember the exact date." Was this work by Mr. Mills which we have been discussing the occasion of your hearing of the acidizing in 1922? Is that the work that you referred to? A. That is what I had in mind, yes.

Q. That was the work that you referred to in your testimony of yesterday? A. Yes.

Q. It would appear from your testimony that you had had some earlier knowledge of acidizing, in 1918, is that correct? A. Yes, sir.

Q. Who did that work? A. While I was stationed at Bartlesville, one of the oil operators asked me to go out there and witness a test of a well by a couple of men, I believe they were from Kansas City. I went out there, and they poured some acid down in the well. I don't know whether it was inhibited, or not, but it made quite a commotion.

Q. Do you know what kind of acid it was? A. It was hydrochloric, I believe.

Q. What makes you believe it was hydrochloric acid? A. Well, just from the reaction, but I do not know positively. I did not pay much attention to it because it was just an experiment, and I was very busy with other things at the time. But I afterwards made inquiries to find out what had happened to the well.

Q. When, how long afterwards? A. A few weeks afterwards. I found out, or, I was told that they had treated a couple more wells, but the effects had not been worth while, and I heard no more about it.

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Q. That could be true today, the same thing could happen today with the present methods of acidizing, using the present materials, could it not? A. You mean that no worthwhile results would be obtained?

Q. You could go out to some wells and give them a treatment, treat them, acidize them by these modern materials, and get no favorable results? A. That sometimes happens, yes.

Q. That is all you know about that operation in 1918? A. That is all I remember of. I do not believe there was any reports came to my attention after that.

Q. You say the results were not worthwhile. You mean by that that the action of the acid on the formation did not accomplish any useful or practical purpose, is that what you mean? A. The owner of the wells reported to me that the results were not worth while, meaning that they had not increased production enough to make it worth his while.

Q. You did not hear anything about any difficulty in connection with corroding the pipe, did you? A. Nothing came to my attention.

Q. How much oil, and what percentage of the oil in the ground is supposed to be recovered today, as compared to 1925? A. By the use of better methods, and because the fields naturally are more conducive to high recoveries, recoveries are much higher today than they were at the time that I wrote that bulletin. (PX-7.) I would say as an approximation that the average recovery was of the order of 40 per cent of the oil originally in the ground.

Q. Over what period of time? A. That is to exhaustion, by present methods which are in use. When I say that they are recovering 40 per cent from the ground, I mean within the economical life of the wells. For instance, the East Texas field was discovered in the latter part of 1930 and is still producing. There are various estimates as to the percentage of the oil in that field that has been produced up to date. It is about 30 to 35 per cent of its ultimate. That is due, in part at least, to the fact that the

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wells are largely shut in, and not allowed to flow to their capacity, or to be pumped to their capacity. That is, they have gotten about a third of the oil out that I think they are going to get out. As to how much of all the oil that is in the ground they expect to get out, the East Texas field happens to be an unusually favorable field for high recovery, and it has been operated in such a manner that this manner of operation is favorable to high recovery, and probably they will get over 50 per cent of the original contents. I would say that this Texas field is a good example of the fact that I called attention to in my testimony yesterday of the obtaining of a bigger percentage of the oil in the ground now than was customary fifteen or twenty years ago. I have not heard of acidizing being employed in that field to any extent. I never heard of any acidizing there.

I know of the Signal Hill field in California. It has been a very remarkable field, an outstanding field in the oil industry in this country. They started producing in that field about 1920. That field covers the top, or mostly the top of one hill. My recollection is that about 600,000,000 barrels of oil has been produced from that one hill or one field. I don't know what proportion of the oil that is supposed to be in that field has been actually produced and gotten out of the ground. I have heard that it is cited usually as an example of the best recovery of oil that has been accomplished up to date in any given field. That it is the best recovery per acre, but as to the percentage of recovery I don't know.

My calculation of comparison in the amount of oil produced today as compared with twenty years ago, in comparison with what is in the ground was a broad estimate. I didn't go into details. I would not be willing to accept the Signal Hill field as having one of the best records in the oil industry in regard to per cent recovery unless I knew more about it, because they had a tremendous thickness of sand which would have given you that high recovery in barrels, but might have been a low recovery in per-

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centage. As to whether the percentage recovery may have been very high, I couldn't say. I have no figures. I never heard of any of the wells on Signal Hill being acidized. It is not the kind of property that acidizing does much good on.

The Court:

The reason for that situation that you have just told us about is because the formation can't be eaten by acid, or what is it? A. Yes, sir. The formation is a sand and not a limestone and that is true, also, of East Texas. Yes.

By Mr. Lyon:

Q. Now, you gave us a figure yesterday to the effect you thought it would take about twenty-four hours for hydrochloric acid to eat through a piece of oil well pipe. You intend it to be understood that that was merely a guess, that you did not have any basis for that figure, isn't that right? A. That is true.

Q. You don't actually know the rate at which hydrochloric acid dissolves or corrodes iron, do you? A. I have looked that up at various times, but I don't remember it right now. I will have to look it up again.

I couldn't say whether, if you fill a pipe with hydrochloric acid, a piece of oil well tubing, there would be enough acid in it to corrode through the pipe before the acid exhausted its power. I understand that in this acidizing, they usually take precautions to see that the acid does not come in contact with the casing.

REDIRECT EXAMINATION

The case I spoke about in Bartlesville, where they put acid down a well, it was a sandstone formation, so that all it could have done would be to wash the surface.

In the Bureau of Mines, the Petroleum Division that I spoke of is subdivided at least so there is a department for refining processes, and one for production processes, and there are several others. The Bureau of Mines studies and reports on refining methods just as fully as it does on producing methods.

These fields Mr. Lyon asked me about as having particularly high production—East Texas and Signal Hill, both are sandstone formations.

The Court:

So far as this acid is concerned, you couldn't use it?

A. Not this acid.

The Court:

It likes lime? A. Very fond of lime.

The Court:

And therefore it is useful, as I understand it, you get a sandstone with limestone formation in it, it will break that down and weaken it because it eats out the lime part of it, is that the theory? A. It has had a little success in sands which are cemented by lime.

The Court:

It would eat out the lime but wouldn't touch— A. —touch the sand, but it hasn't been generally successful.

The Court:

Let me find out what you think happens. Now, take the ordinary limestone, is it pretty pure so that it takes in this chemical and forms a new chemical? A. Yes, it forms calcium chloride.

The Court:

Well, would that be a liquid or solid? A. That is soluble in water.

The Court:

And is there water enough down there? Should I have a picture that it is eating this rock and then it is becoming filled with water in there? A. According to the statements made yesterday, they use a 12 to 15% acid—that means 12 or 15% of it is acid and the rest of it is water. So it is a solution of acid.

The Court:

And then they pump that out? A. They pump the spent acid out of the well.

Sometimes these formations we call limestones are dolomites, a mixture of carbonate of lime and carbonate of magnesium. Both of those dissolve in the same solution, except the dolomites dissolve more slowly.

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The introductory paragraph of Bulletin 351 of the Bureau by Judge S. Rice, published in 1932, entitled "Mining Petroleum by Underground Methods," which reads—

"The methods of extracting petroleum from sands or sandstones of wells have been studied for years, but while methods have been greatly improved in the last decade the present percentage of extraction of the total amount of oil and sands according to various petroleum authorities is usually only ten to thirty per cent. If stimulative methods are used under favorable conditions the recovery may be greater," represents a generally accepted view as of 1932.

The term "sands" is used very loosely in this business, and is frequently used to cover limestone, or anything else, dolomites, or anything that is an oil-producing formation. It is sometimes used to cover anything that will produce oil, any formation.

JAMES W. REBBECK,

a witness called by plaintiff, testified as follows:

DIRECT EXAMINATION

I am employed at the Dow Chemical Company, Midland, Michigan, in the Patent Department, and have been in its employ since March of 1928.

I graduated from the University of British Columbia in 1920 in the department of Chemical Engineering with a

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degree of Bachelor of Science. Then I entered the University of Toronto in the fall of 1920 to take some postgraduate work in chemistry there. I was attached to the faculty of the Department of Chemistry of the University of Toronto from 1920 to 1923, and in that interval obtained the degree of Master of Arts. From 1923 to 1926 I was on the faculty of the Department of Chemical Engineering at the University of Toronto. I also engaged in postgraduate work during that time in physical chemistry, colloidal chemistry and organic chemistry, and from the year 1920 to 1927, while at the University of Toronto I conducted a number of researches on the electrolysis of glass and some other subjects. After leaving the University of Toronto I entered the Mellon Institute of Industrial Research at Pittsburgh, Pennsylvania, and from there I went to the Dow Chemical Company as a research chemist.

In the beginning I was hired by Dow to engage in research on industrial chemical problems, particularly in connection with calcium chloride manufacture and uses, chlorine production, bromine production, iodine and other inorganic chemicals; and then I was transferred to the problem of corrosion, scaling, and other problems in connection with the power plant over there in Midland, Michigan; water purification. Then I was transferred to the metallurgical department, and engaged to study the metallurgical problems in connection with magnesium. Then I was transferred to the fabrication department handling the manufacture, casting, forging, rolling, and so forth, of magnesium and its alloys. That is what they call the Dow metal, that being the trade name for a series of magnesium base alloys manufactured by the Dow Chemical Company.

Thereafter I was transferred to the patent department, and began studying the patent art relating to magnesium. From that I entered the patent angle of the business of treating oil wells and gas wells, and related wells. That necessitated studying the patent art relating to those matters. I made a number of compilations of United States patents in that field.

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The files of the Dow Chemical Company in that line and in other lines relating to the production of oil are complete, so far as I know, in that special phase of production wherein a well is treated with some material by introducing the same into the well. It includes in connection with that other related topics, such as repressuring, the use of heat in oil wells, chemical and non-chemical solvents. I haven't a complete collection of the publications in that line, but the patent collection, so far as it relates to the use of materials in wells for some purposes is believed to be quite complete.

I have heard most of the testimony of Mr. Lewis regarding various methods which have been tried in this country for increasing the production of oil and can refer to patents illustrative of the various methods to which Mr. Lewis referred. I brought with me a collection of United States patents that represents a selection of a much wider and larger number of patents, and these, I believe, are very typical of the sort of patents in this field. For simplification in considering them I have classified them into six different groups, main groups. The classification that I have adopted is as follows:

First, the use of heat in a well, and I have subdivided that into 3 groups, where the heat is generated in the well, or, 2, generated in the formation, or, 3, where a surface heated heat transfer agent is introduced into the well.

The Court:

What does that middle one mean? A. That is where the heat is produced. Passing an electric current through the rock is an illustration of the middle classification, namely, the generation of heat in the formation.

The second main division is the use of solvents, and these may be subdivided into two classes—first are chemical solvents. For example, hydrochloric acid, which chemically dissolves the rock; and, second, nonchemical solvents such as gasoline and the like, which works like water on sugar.

The third main division is re-pressuring. The fourth,

flooding. The fifth, vacuum. Then the sixth is the catch-all, or a miscellaneous group, such as the use of hammer blows; another is a type where water is flowed toward the well, and, according to the theory of the inventor, the water is supposed to carry oil with it by adhesion. Another example is a patent issued to Van Auken Mills, about whom we heard some testimony; and that has to do with preventing water infiltration into wells, although there is an incidental mention of the use of acid, the purpose not being stated.

I have not included mining operations in any of these classes. As I said before, these are in connection with patents wherein something is introduced into a well. Now, I do have some information about patents on mining. I have here a collection of patents, maybe some twenty-five or thirty of them, more or less on the subject of what might be called oil mining, wherein one carves out the oil bearing earth or rock to recover the oil from the carved-out portion; or produces caves, channels and the like in the oil bearing rock to produce drainage galleries, through which oil may be collected and be brought to the surface of the ground.

Q. Will you proceed with your classification, and call attention to the approximate number of patents in each class, and select one of them as typical, and explain it to the court, please confine your answer to patents issued prior to 1932. A. Under the use of heat, my first classification, Subdivision 1, a typical example is an early patent issued to Edward L. Roberts, patent No. 47,458, dated April 27, 1865. This device is for bringing an explosive charge into the bottom of a well where it can be exploded and shatters the rock. Now, A. E. L. Roberts, I am advised, also obtained a patent on his method in 1866, patent 59,936, copies of which are on order at the patent office, where I would be able to show that he had a patent on a method of increasing the capacity of oil wells, which was based upon the use of a device of this kind, or the shattering of the rock by an explosive.

Another example of a patent in this class, one issued to

Butler G. Noble, No. 105,590, dated July 19, 1870, from which I quote the following: "Many wells after yielding oil in large quantities, gradually diminish in productiveness and ultimately cease to produce in paying quantities. This failure in yield is not always because of exhaustion of supply but results from the clogging up of the seams or natural ducts leading into the well bore by the deposition of paraffin and perhaps other carbonaceous matters." And he proposes to generate heat in the well hole to melt out these deposits, heat being generated by the combustion of slow burning gunpowder or something of that type.

Another example more or less typical in this field is the patent issued to James Dickey, No. 106,793, dated August 30, 1870, for improvement in removing deposits from wells, and his proposal is "introducing the gas to the top of the well and firing it thereat. When the well is cased it immediately ignites the deposit in the interior of the well casing and burns downward consuming as the fire moves downward, and the burning ceases when the paraffin is consumed." That was to take it off of the inside of the tubing. The gas referred to here is something which would support combustion. It isn't the gas from the well. The gas that is introduced here is for the purpose of setting fire to the paraffin deposits which are in the well. His invention is based upon this, in that it consists in burning out the paraffin by means of oxygen or other combustible gas introduced into the well by pipe or otherwise, and igniting it in the presence of the paraffin so that it would be necessary to put in oxygen or air, or some combustion supporting gas, in order to carry this process out.

I had reached the Oliphant patent, Oliphant and Lyndon, No. 797529, in which he proposed to set a fire in the well, which would have the effect of increasing the production.

I will now go to the second section of my classification of this first group of patents, involving the use of heat, wherein heat in this instance is generated in the formation itself, and, as an example I refer to Gardner 1,372,743, is-

sued March 29, 1921. He proposes to pass an electric current from one well to another, thereby generating heat within the earth formation, and that will serve the purpose of moving oil towards the collecting well. He connected the output terminals of an electric generator to the tubing of two wells, that is to say, the positive terminal of this output generator was connected to one of the wells and the negative terminal to another well; the generator, the two wells and the earth formation forming the complete circuit for the passage of the current through the earth. The Court:

Well, how would they fix it so that it wouldn't start to cross long before it got down to the bottom of the tube? A. I don't think he could prevent that. Nature would decide where that current is going to go after it goes in one well and crosses to the other, the path it takes between the two is not under control. You have no control of that. The patent states: "The operation of my improved system for removing obstruction to the flow of fluids in earth strata is as follows: An electric current of sufficient voltage to overcome whatever resistance there may be in the circuit described to maintain a watt output power to increase the temperature at the bottom of said well and in the strata between said wells to a degree sufficient to liquify paraffin, asphaltum, and other obstructing residue of petroleum, and to increase the gas pressure by heat, thereby forcing or blowing movable detritus from out the interstices and crevices of the rock adjacent to said wells."

I come to a new section now where the principle of operation is to convey heat into the well by something that had to be heated on the surface of the ground. A simple illustration of that is the Phlager and Lobdell patent, No. 56,987, dated August 29, 1866. In this case the method of conveying the heat to the bottom of the well is analogous to the hot water coil in a hot water heating system. There is nothing to indicate how deep a well they had in mind. However, if one considers the date of issue of this patent it must be with reference to such wells as were known at the time.

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My understanding of the depth of those wells is that they were relatively shallow. I think the Drake well was 70 feet and other wells were drilled about 450.

Patents of this same type were still issuing as years went on. Here is one dated November 4, 1930, to C. Larsen, No. 1,780,428, the purpose of which was to clean the bottom portions of the oil well by the dissolution and mechanical removal of obstructive matter such as mud, paraffin, bentonite, salts, asphaltum, and other things which frequently fill the crevices and interstices of the formation and thereby prevent the oil from flowing into the excavation. He attains this object by producing in the bottom portions of the well a whirl or vortex of a hot fluid fraction. That is accomplished by lowering a device into the well on the end of a tubing, a device of laterally arranged jets whereby steam is forced down the pipe, force the pressure down into the well and squirt out into the hole.

Now, I pass over into the next group, the major division group 2, under the heading of "Chemical Solvents." I would prefer to pass these over at the moment, as I intend to refer to them later, and go to the patents in this major group, the second division, involving the use of non-chemical solvents, by which I mean solvents of the type that take into solution certain materials without undergoing chemical reaction with those materials. Water would not be one of these, because water as far as I know dissolves very little, if anything, in the base of an oil well, or similar well. If you had a lump of dirt down in there, water would dissolve the lump, but not in the sense in which I am using the word; that is, for example, the operation of taking sugar into solution in water, that is the kind of a solvent I have in mind here, and that reflects the type of solvents that are shown in these various patents. They are solvents that truly dissolve some of the substances in the base of the well.

The most typical of these I have here is a patent issued to Edward A. L. Roberts, No. 119,884, dated October 10th, 1817. He sets forth the well known problem that some of

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the others set forth, that the oil bearing rock becomes gradually choked up by the accumulation of paraffin and other substances contained in or deposited by the oil, so that the yield of wells after a time gradually decreases, and he suggests to employ what is here called benzine as a solvent for dissolving those deposits. And, of course, that merely means a distillate from petroleum gasoline.

The Court:

Maybe to somebody else that sounds just as impractical as the heating method, but to my mind that sounds better.

A. This is much better. I know this type of thing is used today for the waxy or paraffinic deposits.

The Court:

I think that sounds as if it might be practical for the thing it is intended for? A. Yes, it is. Coming to the third group here classified by me as re-pressuring, the first one I have here is to Mark D. Mitchell, for oil flushing system, patent No. 825,745, dated July 10, 1906. According to this specification, the method embodying the features of the invention consists in supplying and driving the medium under pressure to the oil bearing stratum, within an effective radius or proximity to one or more oil well pockets. The compressing medium used for this driving effect may consist of air, gas, or other fluid, to which may be imparted a force sufficient to overcome any laxity in the forceful operation desired in the pocket or chamber by an extended, long conveyance to the hole or opening.

That art continued to develop, patents issuing, for example, to I. L. Dunn, 1,067,868, dated July 22, 1913, in which he proposes to pump back into a well a quantity of gas until he restores the pressure. He proposes to pump gas back into the formation where it re-dissolves, dissolves in oil, and then after he has thereby restored the rock pressure, then he will open the well and allow it to produce. Of course, he would get back some of the gas that had been pumped in, but after a time the oil would enter the well because it would be carried through the hole by the gas seeking to escape from the oil in which it had dissolved. This

one is not the drive type. The drive type I think is the one that was referred to by Mr. Lewis, wherein the repressuring gas is put inside, put into certain wells, but the oil is recovered from some other, to which the oil was driven; but in this instance he puts the gas down the same well that he later withdraws the oil from. Now, the patentee states that natural gas may be the pressure medium employed "or I may use any other permanent gas which may be cheaply manufactured but preferably I employ air which when forced into and through the rock upon its return not only has the effect of driving out the oil but also absorbs the lighter hydrocarbons to a greater or less extent thus becoming an inflammable mixture which may be burned or used for any of the other purposes to which carbureted air is put or, if preferred, the gasoline or other hydrocarbons contained in the air and which are capable of condensation at ordinary temperatures may be condensed, the air thus forming a convenient source of volatile hydrocarbons."

Now, this pressure restoration or injection of either air or hydrocarbon gas as the case may be, is effected by large pumps and that is being done on a large scale in many fields. They use several thousand horsepower of compressors turning gas back into wells to re-pressure pools. Of course, this process is directed to a single well, but a whole pool may be re-energized this way. The injection pressures used may run up to two or three thousand pounds per square inch, and they use two or three stage compressors to reach that pressure.

Regarding the length of time that will be consumed in making one of these repressuring operations, the patent states beginning on the last line, column 2, page 1—"But in any event the forcing is ordinarily continued until the required pressure is attained and may extend over a period of several weeks, months, or even longer. During this forcing operation, of course, every effort is made to retain the pressure and prevent the gas escaping either at any of the wells or elsewhere."

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Mr. Lyon:

Just for the purpose of the record, your Honor, can the witness identify for us a particular location or particular type of operation as being used such as he has described, so we will know what he is talking about? A. I have reference to some of the recent issues of the Oil and Gas Journal. In fact, you can find advertisements on these repressuring pumps in almost every weekly issue that comes out.

Patent 1,735,646 dated November 12, 1929, issued to James O. Lewis, is another example of repressuring. The particular feature of this invention is a method of using air and natural gas alternately and in such manner as to avoid the formation of explosive gas mixtures during the injection.

As to whether that was the Mr. Lewis who was on the witness stand, there is no way of telling that from here, other than the printed matter which appears on the copy. I will read that. "James O. Lewis, of Tulsa, Oklahoma, assignor by mesne assignments to Dunn & Lewis of Tulsa, Oklahoma, a partnership, composed of Ervin L. Dunn and James O. Lewis."

Mr. Owen:

That, I think identifies him, Your Honor, he having testified as to that firm name.

The Court:

Yes, and that his name was James O. Lewis.

Another patent, issued in this classification is 1,816,260 dated July 28, 1931, to Robert Edward Lee, in which he proposes to drill lateral channels from a well at one level in the producing formation and then another set of lateral channels in the same formation at a lower level, and then inject gas from one set of channels to the other to force the oil out. And this type of thing continued on until I have here a patent to Robert E. Strait of Bartlesville, Oklahoma, assignor to the Empire Oil & Refining Company, 1978655, dated October 30, 1934, issued on an application filed November 27, 1926. That keeps it within the date that you

have requested, Mr. Owen. This has to do with increasing the production of hydrocarbons from oil wells in which a gaseous pressure medium is forced into hydrocarbon-bearing strata penetrated by the wells.

That now brings me to the patents in Class 4 entitled "Flooding." In this connection I might state that I have very few patents, in fact, I only have three. But it illustrates the fact that there are such patents, and, of course, we know there are such processes. This patent in this class, which is an indication of the type of thing, is 1,651,311, dated November 29, 1927, to Howard Atkinson, for recovery of petroleum from oil bearing sands. With reference to this invention of his, in connection with oil bearing sands, from which it may be difficult to extract the oil. He means sands in the broad sense. It may include acid soluble production formations, or non-soluble, or both. However, the use of this type of process has generally been confined to such formations as are practically not soluble in acid, as the sandstone comes within the type of porosity enough to carry out one of these processes, whereas limestones are like this desk, they are very impervious, they may crack, but they are not very porous.

Mr. Lyon:

Do you have in mind in that connection the flooding as they practiced it in Pennsylvania for forty or fifty years, to increase the production of the wells there? A. That is the type. This patent is not a very good example of that, because it relates to improvements in connection with that. It is not the first or earliest patent on this subject. In the patentee's words, he states:

"The object of the invention is to provide a method whereby oil or petroleum may be extracted with facility and in profitable quantities from oil wells from which oil has been extracted until they have ceased to produce oil in what is generally considered to be profitable quantities, and especially from oil wells which have become flooded with water and abandoned, as, for example, so-called edge water wells. * * *"

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"The present invention provides a method whereby a large quantity of the oil which will not drain naturally from the oil bearing sand and hence remains after the extraction of oil therefrom in the usual way has been completed is recovered. It is based upon the discovery that when a mass of sand wetted with oil or petroleum is at ordinary temperatures submerged in water to which is added any strong alkali, the oil contained in the sand is within a short time removed from the sand in a body, leaving the sand practically clean and free from oil."

The Court:

Tell me in your own way how it is that they propose to get the oil out of this rock. A. They will introduce into one or more wells this water, and while that is going on they will pump other wells in the vicinity of the injection well. They put that water in under pressure, if necessary. In some instances they let it flow in by gravity from an upper stratum. The water stratum up above might be tapped by holes in the casing and let that water run down and it will enter the oil bearing stratum below and force the oil into the recovery well which can be collected in this pool.

Mr. Lyon:

What you call water drive, isn't it? A. That is the common term, yes.

The Court:

They put the water, we will say, into this hole without pressure, the tendency would be, if nothing happened, for it to rise to an equal height in some other well that they pumped the water out of. A. Yes.

The Court:

And the tendency would be that as it picked up the oil on its way, the oil being lighter would go to the top of that, I suppose. A. I think that would be a correct theory of that.

The Court:

With some success, possibly.

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Mr. Lyon:

Of which you take judicial notice. It is in the 1880 census. They published an elaborate book or volume of the 1880 census describing all the methods that the Bureau of Mines then knew that they were using in the oil industry in the United States. You find a full account of this water drive in there.

Mr. Richmond:

The idea is to put in your water over one edge of your field or whatever you are going to drive for, and drive it towards your next well, and when the water shows up there you go ahead and put your water in there and go ahead and take it out of another well.

The Court:

How far? It wouldn't exceed a mile, would it?

Mr. Richmond:

I don't think it would be that far, Your Honor. I don't think it would be over a quarter of a mile.

Witness continuing:

I believe we have covered enough as to flooding to illustrate the type of process that is, and now we come to this last, second to last group, namely, No. 5, in which I have put the vacuum type process. I have one patent here illustrating that, No. 1,858,847 dated May 17, 1932, to P. L. Young. He proposes to connect the well casing to vacuum pumps and at the same time by the injection of a gas down a tube and through nozzles in the bottom of the hole, to create suction down there. They are both done in the same hole. He is withdrawing a gas from the hole at the same time that he is using a gas jet pump in the bottom of the hole. He is producing the maximum possible vacuum at the bottom of the hole because it is there that he operates this jet pump which does the sucking, in addition to the vacuum pump that is at the top of the well. It aids in getting the most reduction in pressure that he can get in a well hole.

The Court:

Does it mean, then, that he has a suction at the top and

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there is another suction at the bottom? A. It makes it easier for his purpose apparently to do it that way. But, he cannot, in any event, secure a greater reduction in pressure than the lifting off of the atmospheric pressure. All that anyone can do with a vacuum pump is hold off the atmosphere, and that is all he is doing but in a complicated way.

The Court:

He was figuring, perhaps, that the suction of his pump at the surface wouldn't be big enough so that when he got to the bottom of his well his vacuum wouldn't be very good. A. There is something in that, I believe. He states in his own words that, "The present method is an improvement of the processes for obtaining gas and vapors from oil wells under high vacuum by which higher vacuua may be obtained in an extremely efficient manner directly on the producing sands." That is his view of what it is he is trying to do. However, this patent is illustrative of the fact that there are patents in this field of vacuum operation of wells.

Then that brings me to a miscellaneous class of more or less unrelated things that might be done in an oil well in connection with extracting oil from the ground. The first one of these is dated 1865, No. 49,922, to Isaac Relf, and it involves the use of pressure produced by hammer blows of a piston inserted down the well hole. That was just to compress the air, making shots of compressed air at the bottom. The Court:

Awfully small around the opening. Isn't that what he is hoping for? A. That is what he is hoping for. It has almost a mechanical way of getting the action of an explosive.

The Court:

In other words, it is different from what you had before of compressed air? A. Yes.

The Court:

But this is to compress it in shocks? A. That is the sort of thing it is.

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The Court:

I should think that would almost come under compression, that is, air compression, or something— A. Yes, it could be, although it is a mixture of the mechanical and so on.

The Bureau of Mines has put out a publication dealing entirely with the vacuum operation of wells, and it is a better publication of that art than one could find in the patents themselves. I believe the date is about 1930. It summarizes the past history, of course. It shows that vacuum has been used on wells for many years in different places, as one of the methods of stimulating the recovery of oil.

Mr. Owen:

I am now going to make the offer of the copies of each of the patents referred to by the witness, merely for the purpose of illustrating what the witness has testified to, and for the convenience of the court, if he cares to look at them. When it comes to an appeal record, I, of course, do not expect to put them in.

The Court:

I will say this about the appeal record, they are not to be printed in that record.

That would be too expensive, and you ought not to do it. I have the privilege of looking at these in connection with this testimony. I doubt if I will find occasion to do it, but I have that privilege, and I reserve that same privilege for the Court of Appeals.

The Court:

By the way, which one of these classifications now does our method here in suit fall into? A. That was under the solvents, and I excluded that class from my discussion.

I can't place an exact number on the patents in these classes. But as I said before I believe my files of patents relating to the production of oil by means of wells cover some two thousand or three thousand patents. Those specifically directed to methods of treating wells involve some two hundred patents and, of course, the ones that I selected

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out of that are a smaller number still. But, I did not include in the patents referred to those involving the use of chemical solvents. This will be up to June 30, 1932.

Mr. Lyon:

Are these all the patents there are in the Patent Office on those subjects, or just the number you happened to have when you made the estimate? A. Those are all I have found in connection with my business of locating these patents.

Mr. Lyon:

Now, similar patents or patents on this same subject have continued to issue since 1932, have they not? A. Oh, yes, indeed, and are still being issued today. There has been an enormous increase in the rate of issuance of patents since the issue of Patent 1,877,504. That is the Grebe-Sanford Patent in suit.

Mr. Lyon:

You mean in all of these different fields? A. No, in the special field of the use of acid in a well.

Mr. Lyon:

But how about these other fields; have the patents continued? A. They have been coming out, but I don't believe that the rate has been anything like—there has been a growth, of course, but the rate of growth there is nothing like what it has been in that special art.

Mr. Lyon:

What I am getting at is this: Since 1932 patents have continued to issue in these classes that you have mentioned here today, at least as fast a rate as they did before 1932, and to some extent faster? A. I think that is correct, although I haven't specifically computed those rates.

By Mr. Owen:

Q. Now, will you take up the field of patents in which solvents of one kind or another are used and which I understand you omitted from your previous classification? A. I omitted the solvents which I have called chemical solvents wherein the solvent action involves a chemical reaction, too.

Q. Will you take up that line of patents and explain

approximately how many there were prior to 1932, and what they cover?

The Court:

Does this question apply to just chemical solvents, or all kinds of solvents?

Mr. Owen:

Chemical solvents.

The Court:

That means where there is a chemical reaction?

Mr. Owen:

Yes, Your Honor.

A. My recollection as to the number is that there are about ten such U. S. patents. I may be in error by one or two, but they well—the correction will appear as we go on.

Up to June of 1932, or the filing date of the Grebe-Sanford patent in suit. The first of—

Mr. Lyon:

(Interposing) Would you give us at the same time the number that have issued since? A. Yes, I can tell you approximately. I think there are 71 more issued from the period of—that is, on applications filed since June 30th, 1932, until some time in 1939, there were about 71 patents issued on applications filed during that interval, while there were about ten patents issued on applications filed in all the previous interval up to that time.

Q. (By Mr. Owen) And what is the distinguishing feature that applied to those ten patents issued prior to 1932 and those 71 patents which have issued since on applications filed since 1932? A. I am not sure that I understand the question, Mr. Owen.

Q. Did all of them utilize acid in a well for one purpose or another? A. Yes.

Q. And then, as I understand you, the number of patents in which acid was introduced into the oil well, or any other kind of well, prior to 1932, was ten, and that since 1932, the year when the Grebe-Sanford patent issued, there have been 71 patents issued in that respect?

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The Court:

Eighty-one; 71 on applications filed since that date, and ten on applications that had been filed prior to that date.

Q. (By Mr. Owen) Do you understand? Is that right? A. That is my statement, subject to perhaps the correction of a few numbers one way or the other.

Mr. Lyon:

Your Honor, can I ask a question? Are you speaking now of all patents using acids to dissolve formations, or wax, or some material on the formation, or are you talking about all patents involving any kind of chemical solvent, whether it is the acid or not? A. My number I gave was limited just, subject to correction, to such patents as involved the use of acid in wells for any purpose. They are limited to acids with or without other things.

Mr. Lyon:

Aren't there a great many other patents that show one kind of chemical solvent besides acids for use on a well. A. Not as far as I am aware.

Mr. Lyon:

Have you looked for them? A. Yes, sir.

The Court:

Just give one example of what you have in mind?

Mr. Lyon:

Some of these Tretolite patents. Tretolite Company has a whole line of patents for paraffin removing that are not all limited to acids. A. I don't know of any that are involving the use of acid in a well.

Mr. Lyon:

That is where I am mixed up here somewhere. They have a line of patents on the use of solvents for putting down wells, have they not, the Tretolite Company? A. I am not aware of it, that they have such a line.

Mr. Lyon:

Well, they have. As you say, has your search been such that it would reveal whether they had any or not? A. I believe it would have.

Mr. Lyon:

Then you say they have not any patents on solvents for removing paraffin from wells?

Mr. Wiles:

He said chemicals.

The Court:

Chemical solvents? A. I do not know of any.

The Court:

Just call his attention to one.

Mr. Lyon:

I have not got them here. I will have to get them and give them to Your Honor. There is a whole series of them.

The Court:

Then you find one and bring it here before you get through with it, and call it particularly to his attention.

Mr. Lyon:

Yes.

Mr. Wiles:

The witness has limited this to chemical attack.

The Court:

That was the reason I did not know but what there was some misunderstanding.

Mr. Lyon:

I think there is.

The Court:

I think it would be better if we could solve it at an early time. As quick as you find a patent that will illustrate what you are asking him about, call it to our attention.

Mr. Lyon:

Are these chemical solvents limited to those that will attack paraffin?

Mr. Wiles:

They will attack something—

Mr. Lyon:

For instance, mud, in a well, a well is muddied up, and you want to get some of that mud ~~out~~ as to open it up so that it will flow better. They use a chemical for that.

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Mr. Wiles:

Chemicals that will attack something and make a chemical change.

Mr. Lyon:

Then maybe I have misunderstood you.

The Court:

That is not the chemical solvent, is it? That is what I was in doubt about. They explained to me a little while ago, and I think I was asking some questions that if mud does not enter into a chemical change, but it just entered into a solution, or whatever you call it, it would be in the water, and that would suspend—is that right? A. That is right.

The Court:

That would be anything that would soak mud up, soak down the lump and let it float around in there, but that would not be included in the chemical solvent any more than it would if they put water in there and stirred it up?

Mr. Lyon:

(To the witness): Is that the reason that you eliminated from this class some of these Tretolite patents, or didn't you look at the Tretolite patents? A. I believe I have a couple of hundred of Tretolite patents in my collection, and I looked at them.

Mr. Lyon:

Some of them would have come into this class if it were not for this feature of solution? A. I can think of one or two that might have. There is one of the Tretolite patents—I don't recall the exact date, whether it is 1931, perhaps, or 1933, somewhere along in there, which involves the use of minute amounts of carbon tetrachloride in the water introduced into the well while it is producing, to prevent the formation of paraffin deposits. But, as far as I am aware, there are not any Tretolite patents that have to do with the use of an acid in the well for any purpose, or that have to do with increasing the production of a well in any way.

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Mr. Lyon:

Do you happen to remember one, a Roberts patent, on putting a modified fatty acid down the hole to prevent the formation of emulsion that would interfere with the production of oil? A. I think there are quite a few such patents. As I understand their disclosures, they have to do with treating wells that are producing and while they are producing. It has nothing to do with the art that I have collected here.

Mr. Owen:

I have a chart, if Your Honor please, prepared by the witness to illustrate the point that has just been brought out. It is a little bit out of the order in which I intended to produce it, but in view of the fact it has now been brought out, I will have this chart marked Plaintiff's Exhibit 9 and will ask the witness to explain what it shows.

(Marked Plaintiff's Exhibit 9.)

The Court:

I will say this to counsel for Halliburton, any time you find such a patent I will be glad to stop and let you interrupt to let you show it to the witness and inquire about it, if you do find it.

A. This chart shows by this scale on the left the number of United States patent applications which issued into patents. The scale along the bottom is the year, corresponding to that number. The curve has been plotted with reference to these two scales, beginning in the year 1865, because that was the first year at which I found an application issued into a United States patent mentioning the use of an acid in a well. That was the Sherwood patent, issued in 1865. Then around this time (indicating) more patents issued, and as more issued and as time went along, this curve went up very slowly.

By Mr. Owen:

Q. How many had issued up to 1900, say? A. By 1900 there had been 5 patents issued on applications filed up to that time. Then we come to about what appears to be 1922 on the chart we perhaps have six or seven patents

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issued by that time, six perhaps. The exact number we can determine by a reference to the issued patents and counting them up. We get along to 1930, there were then 10 issued patents on applications filed up to that time, and then I believe there were no more issued until the Grebe and Sanford application was filed and issued. Thereupon there was an enormous immediate growth in the number of applications issuing into United States patents, so that by 1939 there were more than 55 patents that had issued on applications filed up to that time.

The line indicating the issuance of patents involving the use of acid in a well since 1932 does not include patents that issued on applications filed by the plaintiff, The Dow Chemical Company. From this chart have been excluded the plaintiff's applications. But in the numbers that I have previously mentioned in my testimony I have included all the patents that I know about.

The Court:

You say you excluded applications of The Dow Chemical Company? I understood this was a chart of patents issued? A. Yes.

The Court:

Does it include patents issued to Dow? A. Only the Grebe and Sanford. And this chart shows nothing about pending applications. These all have become patents. The chart is according to the dates when the applications were filed. It is patents issued but it is by filing dates. The chart does not include any application which is still pending nor any application which has been rejected and abandoned during this period, because my numbers are taken from issued patents.

The Court:

But you have gone into this and if I were to make another little dotted line here (indicating) that showed the date patents issued, that would come clear up to today over into the '41 column, it would be here? A. Yes, sir. As a matter of fact, the steepness of the curve which shows the rate of growth might be steeper than this is, because that

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might bring out still more patents pending we don't know anything about.

By Mr. Owen:

I have another chart which I will ask to be marked Exhibit 10. (Exhibit 10 marked.) This chart will be referred to as Streams of Knowledge Chart. I will ask the witness to take up, first, the patents which are listed under the title Stream 'B Knowledge of the Use of Acid in Oil Wells, in view of the fact we have just been considering that subject. That is the column on the right of the chart. A. The first patent in that column is 57,982 dated 1866 and it is for improved method of removing obstructions from oil wells. That patent teaches to bring acid into contact with an obstructing tool which may be in the well hole, for the purpose of eating away either the tool or the surrounding rock, or both.

The Court:

You can loosen it and get it out? A. Yes, or if you wish, you may dissolve the tool completely in the well hole. The corroding and the decomposing action of sulphuric acid upon iron and steel is well known and it is used in this process, or any equivalent acid. The acid is brought into contact with the obstruction by means of a small tube, and then—or, it may be brought into contact with the obstruction by means of a glass bottle or cylinder, the bottle being allowed to strike the obstruction and break, and empty its acid contents on it, thereby dissolving and making it possible to remove the tool. The acid is described as hydrochloric. That would take care of hydrochloric particularly, as it has a similar economic status and it is presumed to be similarly corrosive. It was broad on any kind of acid that would eat iron.

The Court:

Or any kind of rock? A. Or the rock.

The Court:

So that if they had a rock that some acid was particularly good for, they could use that kind? A. That is true. As he states,—“The acid will also act upon the rock

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and will decompose portions thereof in which the tool is wedged and thereby quicken and render more easy this method." He also states in connection with introducing the acid, a copper barrel may be used to lower the acid to the obstruction.

The next patent on the list is dated 1873 to Looney, No. 139,010. His application was filed in 1872, and he makes use of an acid in an oil well to generate heat by reacting the acid in the well hole with an alkali. Potassium hydroxide is the alkali, although the patent uses the old language, a solution of potassa. That substance, of course, is a solution of potassium hydroxide.

By Mr. Owen:

Q. What does that patent have to say about how the acid is gotten into the well? A. I don't recall finding any special instructions about introducing the acid into the well. It should be noted, however, that he first places in the well this alkaline solution, and, of course, that will neutralize the acid subsequently introduced. That would not be an inhibitor.

The Court:

What would you say it did? A. It would neutralize the acid. That is just another way of saying it would react with the acid and turn it into something else which is not an acid.

The Court:

The purpose of this, what you have got I see is by that reaction to produce heat and melt something that they thought would plug it up somewhere? A. Yes. The patentee states that his invention relates to cleaning the well of paraffin and other similar resinous compounds which impede the free flow of oil by means of chemical ingredients, and it consists of what we have just mentioned. The sole method of doing it was by the reaction of creating heat and melting the stuff so that it would—

The Court:

Why wouldn't it get cold and go back and do the harm all over again? A. It would. And, he provides for that by

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putting some benzine in afterwards. That keeps the melted paraffin in solution.

The next patent is dated 1896 issued to John W. Van Dyke on an application dated 1895, No. 556,651. The Van Dyke patent relates to a method of increasing the flow of oil wells in limestone formations and that is accomplished by the introduction of sulphuric acid into the well through a special pipe, the acid being then forced into the producing formation where it reacts chemically on rock, producing other material which is removed by subsequently washing out the hole in the formation.

The Court:

This is the first one that does—that attempts to do what our patent in suit does, namely, eating the rock? A. That is correct. It eats the rock in which the oil is coming to the well; it eats the oil bearing rock.

Q. What does that patent state about the means of getting the acid down into the well? A. Well, the patent specification states the following: (reading) “The following is a description of what is considered the best mode of carrying out the invention, reference being had to the accompanying drawings which form part of this specification, and in which—

“Figure 1 is a diagram of a well with the supply or reagent introducing pipe in place.

“Figure 2 is a detail view illustrating a mode of protecting the said pipe; the pipe A is provided with a rubber packer B in the rock above the Trenton limestone C in which the well is. It may be enameled or lead lined pipe, externally coated with enamel or lead below the packer B, or it may be otherwise made proof against corrosion. There is a box D provided with a funnel-shaped bottom to feed the acid to the pipe A. As shown in Figure 2, the pipe A is lined with a tube 2, of soft rubber, and covered exteriorly with another soft rubber tube 3, the lower end of the inner tube being turned back over the pipe A, and also the outer tube, and the whole wrapped to prevent ingress of liquid at the joint.”

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The Court:-

Isn't everybody agreed that that patent that he has just referred to of 1896 is, so far as eating the rock is concerned, exactly like the patent in suit? He had that idea just as completely as the patent in suit, but when it came to preventing the misfortune of that acid destroying or eating the iron of the tools of the well, destroying those, he had an entirely different scheme of matter, isn't that true? Is there anything wrong with either one of those statements, that one is exactly alike, and the other is entirely different? Mr. Owen:

The only addition I would make to your statement is that in this particular patent, sulphuric acid is used instead of hydrochloric acid. The next patent used hydrochloric acid, or is supposed to, but at the same time I want to call Your Honor's attention to the fact that although the action of the hydrochloric acid is the same when it gets into the formation, it is now known to be the same when it gets into the formation whether it is uninhibited or inhibited acid, it was not known at that time, and it was not known at any time prior to Grebe and Sanford patent that an inhibitor could be used which would not in some way affect the action of the acid when it got down into the oil well.

The Court:

Well, I thought that covered my second proposition, that it was entirely different as to how he was going to—he didn't have the idea at all, I thought, of actually protecting the tools.

Mr. Wiles:

That is right.

By Mr. Owen:

Q. Now, take up the next patent and explain that. A. The next patent which issued actually concurrently with the prior numbered patent to Van Dyke is that numbered 556,669 to Herman Frasch who assigned one-half to John W. Van Dyke. Van Dyke also assigned one-half of his to Herman Frasch. And the drawings are signed by Charles J. Hedrick in both instances.

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Q. And, isn't it a fact that the drawings are the same in both instances, and that the specifications are almost word for word in both instances except the Van Dyke refers to the use of sulphuric acid and the Frasch patent refers to the use of hydrochloric acid? A. That is what I gather from the reading of both these specifications. There are differences in statement as to the chemical effects produced by the two acids, of course, because in the Frasch patent the reaction of acid on the rock is to produce a calcium chloride solution out of the rock, whereas the action of the Van Dyke patent employing sulphuric acid is to convert the solid limestone into a suspension of calcium sulphate which can not be forced out of the rock pores.

By Mr. Owen:

Q. Now, will you take up the next patent on that list?

A. There is some of the Frasch specification, perhaps, that differs from the other that might be included. It states that after a rest of, say, twelve hours, milk of lime is pumped down to neutralize any trace of acid that might exist. The well is then cleaned out and the tubing replaced.

The Court:

That was to check further eating. They had the danger that might come if it kept on eating and ate out into the brine, I suppose? A. I presume that is so.

The Court:

Does Frasch also describe protecting his metal in the same way? A. The description of that is practically identical with that in the Van Dyke patent, the means of protection being to employ an enameled, lead-lined or rubber-covered pipe.

The Court:

Aren't there any acids except sulphuric and hydrochloric acid that will do the trick? Aren't there some other acids? A. Yes. There are many acids which will form solutions with calcium carbonate. There are a great many that will do that. But, as to how many acids there are which will dissolve oil producing rock is something I am not prepared to answer.

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The next patent reference on the B side of the chart is a patent to George L. Ball, numbered 670,577, dated 1901, the application being filed in 1900. He makes a disclosure of introducing an acid into a well, and an alkali to react and produce heat. It is similar to Looney. However, this patent discloses also that in order to put the acid in you may employ a dump bailer. The patent states:

"The chemicals may be introduced into the well by dropping or pouring them therein and, as they are heavier than the oil, they sink to the bottom of the well, so that the heat is generated in the cavity where it is required; but the chemicals, or at least the acids, may be put in an ordinary bailer, and lowered into the well and then dumped."

By Mr. Owen:

Q. Will you explain the operation of these dump bailers to which the patent refers? A. I am not well advised in dump bailers. However, it is my understanding that it consists of a length of pipe of such diameter as will enter the well and be capable of being lowered to the bottom, and at the lower extremity of the pipe there is some sort of valve means whereby the contents of the pipe may be emptied when the lower end of it strikes the bottom of the well, by a kind of a trip arrangement.

Mr. Lyon:

It is just a bucket that you can drop on the bottom of the well and it will then empty its contents.

A. (Witness continuing): On the chart there is next shown a 1923 reference of Mills. It is a Bureau of Mines report of investigations, Serial Number 2550, to which Mr. Lewis has made reference in his testimony. It is Exhibit 8. There is a portion of that report that refers to the use of an acid in a well, and my recollection of what I heard from Mr. Lewis is that that portion of this reference has already been read into the record. On page 9 the use of hydrochloric and sulphuric acid both are mentioned. It describes what we have been finding heretofore in the patents, and in addition this bulletin of the Bureau of Mines also makes this statement with regard to sulphuric acid:

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"Sulphuric acid should not be used in oil wells because of the danger of plugging the sands with precipitated sulphate salts, more especially calcium and barium sulphate."

The next reference is patent 1,410,827 issued to William F. Muehl, dated 1922, on an application filed 1920. It is for a method of cleaning oil wells. For that method he states that he uses acid. He introduces a suitable acid, such as hydrochloric acid, which will attack calcium silicate and other accumulations, to clean a well—

The Court (interrupting):

It's the same chemical action we have been talking about but he doesn't seem to be thinking about its going out inland but, more, he thinks this lime from the rock is going to get down in there and into the well proper and he wants to eat that out.

Witness continuing:

That is true. The use of the acid is more local than in the Frasch or the Van Dyke patents.

The Court:

Does he say anything about how he does that? A. Yes, he does. In fact, his specification includes a drawing of an apparatus showing a means for getting the acid to the location where he wants it to work, and it consists of a dump bailer similar to the one previously described, but for the valve in the lower end of the bailer he has provided zinc closures, a form of zinc disk. And these, of course, are dissolved by the acid, thereby emptying the bailer after a time. The discs last long enough to permit the acid to be lowered into the well.

Regarding the number of discs to be used, the patent states that these can be varied according to the length of time that the acid is to be allowed to remain in the bailer.

Quoting from the patent: "I prefer to use hydrochloric acid, which readily attacks zinc, and I prefer to have the zinc wafers or discs of such thickness that a given time will be required for the acid to eat through each disc. By way of example, each wafer may be designed to resist the acid for five minutes; therefore, if it requires five

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minutes to lower the receptacle from the top of the well to the point of discharge, one disc will be placed in the bottom of the receptacle. If ten minutes are required, two discs will be used; fifteen minutes, three discs, and so on."

Mr. Lyon:

I call Your Honor's attention to the fact in that patent, page 2, line 22, the inventor says: "The particular advantage of providing the container is that the acid may be applied locally in the well, thereby reducing the quantity to a small portion of that which would be required if it were necessary to pour the acid from the top of the well." So the inventor was deliberately just putting down a bucketful of acid and calls attention to that is why he uses a bucket—because he doesn't want to use as much acid as would be involved pouring it down the pipe.

Witness continuing:

Another feature about that disclosure is that the size of the bucket which can be introduced is obviously small because he puts it down through the innermost tubing of the well.

As to whether there is anything to indicate the character of the formation in which this invention was intended to be used, I think the disclosure in the specification of the problem that this method was intended to solve indicates that the producing formation would probably be unaffected by the acid because the invention seems to be directed towards removing the accumulation of paraffin, calcite or acid-soluble deposits.

The Court:

And the amount of it indicates, as you say, a small amount, so he evidently wasn't thinking about getting out into the rock formation but getting some accumulation in his well.

Mr. Lyon:

Page 2, line 17, he refers to the lime or silicon or other accumulations on the side clogging the walls or screen will be relieved of the accumulation, and the oil from the surrounding stratum may flow into the well unimpeded. So I

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don't see anything in here to say it isn't a limestone well, because he refers to lime. A. No, I found no reference to lime. It refers to calcium, silicon and other accumulation.

Mr. Lyon:

You don't find any reference to lime? I call your attention to line 17, page 2 of the patent. A. Yes. But that, of course, taken with the statement on the previous page, as to the deposits which are there, would seem to indicate that he is not talking about the structure of the producing formation.

Mr. Lyon:

How could there be any lime in that well along the walls if there was not lime in the formation into which the well was dug? A. There is no necessary connection between the existence of lime deposit in the sand well and the producing formation's composition.

Mr. Lyon:

Well, the lime must come from the formation in the well somewhere. A. That is an assumption.

Mr. Lyon:

What? A. That seems to be an assumption. There is no necessary connection between those facts.

The next patent is one issued to Lake and Phelps No. 1,498,045, dated June 30, 1924, on an application filed in 1923. His invention relates to a process of cleaning wells and apparatus therein, and it has for an object a provision of a novel process which readily removes colloidal muds, clays, etc., from the walls of the well hole or from any apparatus or members within said well hole, and which muds would tend to clog or otherwise obstruct the flow of oil or gas through such apparatus or well hole.

Some acids chemically react with mud, or with clay, depending on the composition of the clay, but in this process according to the specification as I understand it, the way he states it at any rate, is that the acid solution seems to have greater affinity for the colloidal muds than it has for the metal casing through which the acid is introduced into the well hole. It would appear that the acid would re-

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act quite readily with this mud, maybe far more, maybe so readily that it does so more actively than it does on the metallic part of the well.

Mr. Lyon:

Would you read that particular part to the court beginning at line 100, because here is a man that says this acid which includes hydrochloric, if handled properly in the pipe will not injure the pipe. A. I don't gather that from this specification.

Mr. Lyon:

Read beginning at line 100, will you please?

"It is found that the acid or acids used for these purposes will not appreciably attack the metallic structures in the well hole such as tubing and casing, collars, and the like, where mud is present in the hole, unless used to excess, inasmuch as when an approximate balance between the amount of acid and colloidal mud is maintained, the acid action will be expended upon the mud rather than in attacking the metal."

The next patent is Tilton, No. 1,608,869 issued in 1926, on an application filed in 1922, and renewed in 1925. He proposes to generate a heat in a well to melt paraffin using the action of concentrated sulphuric on water followed by a neutralizing sodium hydroxide.

The Court:

Now, what did he have that was new over Looney and somebody else? He had that idea of having a chemical reaction creating heat and melting paraffin. A. There is this possible novelty in it, there may be, of the use of a concentrated sulphuric acid, which, when added to water, liberates a large amount of heat, and then after that heat has been obtained he can get a further kind of heat by neutralizing the acid solution previously formed, using sodium hydroxide for the neutralization.

The Court:

Did he put them in separately? A. Yes.

By Mr. Owen:

Q. What did the patent state or show as to the meth-

ods used for lowering the acid into the well hole? A. It is my recollection that the container used for this was a lead-lined container. The patent states, beginning with line 89 of page 1: "The acid container proper is an elongated receptacle, provided at its lower extremity with a valve discharge orifice 4. The valve for closing the discharge orifice 4 comprises a stem 5, extending through the orifice, and a head 6 lying within the receptacle. The head 6 of the valve comprises a conical lower portion 7 arranged to fit the wall of the container adjacent the discharge orifice 4, and an upper portion 8, which is shown as conical, but which may be of any desirable rounded or tapered form.

"Cooperating with the valve head 6 are a plurality of spheres 9 disposed within the container 1. When the container is lowered into operative position, the valve stem 5 comes into contact with the bottom of the well and moves upwardly within the container. When the valve head 6 moves upwardly, the spheres 9 run downwardly in the container and wedge between the conical portion 7 of the valve head and the corresponding inner surface of the container adjacent the discharge orifice 4. These spheres are of sufficient diameter to prevent them from passing out through the discharge orifice around the valve stem 5, and also to prevent their upward displacement around the valve stem and pass the valve head into the body of the container. If desired, however, the head portions 7 and 8 may be separated by the ridge or bead 10 shown in figure 6 of the drawings, to additionally insure against displacement of the spheres from between the lower portion 7 of the valve head and the inner surface of the container." When the stem 5 strikes the bottom of the well and raises the valve the acid, or whatever liquid is contained in the container, will flow out into the well hole.

The next patent on the chart is the patent to Leo Ranney, 1,806,499, issued in May, 1931, on an application filed in 1928 for a method of facilitating flow from wells. He states, "The invention is especially applicable to the cleaning of oil wells in which deposits of paraffin, calcite or the

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like have obstructed the flow from the oil bearing formation."

Briefly he proposes to introduce into the well an acid and a gas-generating chemical which reacts with the acid to liberate the gas. Specifically, he puts in either hydrochloric or nitric or sulphuric acid or other acids or mixtures and then a charge of this gas-generating chemical, as an example specifically noted here is calcium carbide and that reacts with the acid solution making acetylene, and he also states that he may allow that acetylene to be ignited, thereby obtaining additional heat, that is, heat in addition to that produced by the reaction of the carbide on the acid. He does not state how he is going to get air to ignite.

The Court:

It wouldn't burn, would it, down there? A. I don't believe it would burn. Nevertheless, he would obtain the heat of the reaction of the carbide with the acid. He mentions that there will be parrafin in the well and this invention serves to remove those deposits. Acid and gas do not react as far as I know.

The Court:

I think he was doing probably what we have been reading about before where his acid reacted with whatever was in the well, various things in there would be likely to be something that would react with that acid, and in that way he might clean it out. A. Well, presumably he uses enough acid to obtain neutralization, although there is a statement on page 2 beginning with line 18 as follows: "Since the acid is neutralized or almost neutralized by reaction with the added chemicals or the calcite, etc., there is no substantial corrosion of the equipment." In other words he apparently does not use any more acid than is necessary to use up the gas-generating chemical he has put in, and the deposits of calcite, and so forth, that may be there.

Mr. Lyon:

If that is the last one of the patents on this phase of the chart that you intend to include, might I ask why you did not include patent 1,891,667 granted to Mr. Carr of

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Pure Oil Company on an application which was a continuation of an application filed April 28, 1932? I am sure you are familiar with that patent and the application. The parent application is earlier than the patent in suit. Why didn't you include it in this Stream B, in Exhibit 10? A. That was not prior art to the Grebe and Sanford patent.

Mr. Lyon:

Do you know that of your own knowledge? It is an earlier filed application, and we have taken depositions here which will show the fact. Here is a patent of the Pure Oil Company that describes all about acidizing wells. The evidence in the depositions show that before Mr. Grebe made any invention at all, that Pure Oil Company came over with the idea to—

Mr. Owen:

I beg your pardon, that isn't true. That doesn't show that at all.

The Court:

Strictly speaking, application is not prior art.

Mr. Owen:

No.

Witness continuing: In making up Exhibit 9 I took this Carr application into consideration. In making up that line I also considered Bowman patent No. 1,809,546, dated 1931, but no others.

The Court:

Then there would be twelve. Then he has got this a little bit above, you see. A. Yes, sir, the 12th application to be filed was the Grebe-Sanford.

The Court:

There were 12 applications filed on which patents later or at some time were issued.

Mr. Owen:

There really would be 11, because this Mills is not a patent.

The Court:

Oh, yes.

Witness continuing: I want to make a correction be-

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cause I had forgotten when I made that out as to the number that I had omitted the plaintiff's application. That one is out. So, there are ten, and the Grebe-Sanford patent in suit is the 11th application that was filed up to that time, on which patents at some time issued.

Mr. Lyon:

Well, which one of these kinks on Exhibit 9 represents the Carr application I have referred to? Is that on there at all? A. That comes after the Grebe-Sanford patent.

Mr. Lyon:

You just arbitrarily put it afterward. A. It is chronologically subsequent to it.

The Court:

Which one? A. This Carr patent has a later number. It issued in December. The application was filed on the same day as Grebe and Sanford.

Mr. Lyon:

And it was a continuation of an earlier filed application, so it states. A. The application on which the Carr patent issued was filed June 30, 1932.

Mr. Lyon:

And this application states it is a continuation of a prior application filed April 28, 1932. A. No patent issued on that application.

The Court:

But, it is a continuation of it.

Mr. Lyon:

Yes. My point is if your chart is exactly as good as stated it was, according to my view the Carr application should come here and should affect this curve and change the curve.

The Court:

In other words, it would make this one a little steeper and this one not quite so steep.

Mr. Lyon:

It would also show that this upturn started with the Carr application instead of with the Grebe and Sanford. That is the significant part of it. But, I am willing to just

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have the record show for the present that this curve does not correspond to the curve as it would be if the Carr application was in there ahead of the Grebe application.

By Mr. Owen:

Q. Will you explain what patents issued between 1920 and 1932 which caused the rise in this line on Exhibit 9, and state what those particular patents relate to, that is, just briefly? A. I cannot state the cause which brought on the issuance of these additional patents in that period of time.

The Court:

Well, here is one thing that I see (indicating on the chart): We had just nicely got through with the war and the boom period came on. I do not know whether that means anything in the oil industry, or not.

Mr. Lyon:

It meant a whole lot to the oil industry.

The Court:

You see this upturn here about the time that we got through with the war in 1918, or it may be a little past that.

Witness continuing:

From the point about 1922, where the curve starts to go up, to where it flattens out in 1930 or 1931, very few patents are in consideration in that space. In 1922 the patent issued to Muehl, and that was the sixth application. That is the one at the angle here, right above or just past the 20 mark. The next one was Lake and Phelps, issued in 1924. That is the next point right here (indicating). The next to the right of that, and up a little, is the issuance of Tilton in about 1926. Then the next hump in 1928 is the issuance of the Ranney patent. Then the next is going off to the right, Bowman, 1931. The Muehl patent was dumping acid into a well with a dump bailer to clean out paraffin and calcite deposits and such like. The Lake, et al., patent was for breaking up mud colloids in the well hole. Tilton was for melting out paraffin deposits. Ranney was for melting out paraffin deposits, and Bowman was

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for cleaning the well liner. That had not been mentioned previously.

The Court:

Here's the way I understand this graph has been made. Here he starts with the first patent down here (indicating 1865), the next patent he made a date for that, the next patent, and so on; moving up according to the number, getting at the place in the elevation, representing the number of patents, and the date of the application would fix its date for right and left. And then having fixed all those marks, he just hitched them all together. Isn't that the way you made it? A. Yes, sir.

Mr. Lyon:

Yes, but I don't understand this flat one which apparently separates this portion of the curve from that. It seems to me according to the witness' prior testimony there was another additional application between this point (indicating) and this, and necessarily this curve shouldn't show that break, which, in my opinion, unduly emphasizes something that does not exist.

The Court:

What I am going to do right now, instead of spending a lot of time about it, is to ask that they hand you their book of patents and you make one of those graphs.

Mr. Owen:

I am perfectly willing to do that, and have Mr. Rebbeck make his curve.

The Court:

I like things of that kind. There is that continuity. They might easily make a mistake in that.

Mr. Owen:

At the time of the adjournment last evening, Your Honor, we had been discussing the correctness of the chart, Exhibit 9, and I asked Mr. Rebbeck to make a new chart showing where each patent enters the picture, and we have that here, and I would like to have him explain it to you.

The Court:

We will call that Plaintiff's Exhibit 9½.

(The chart was thereupon marked PX-9½.)

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The Witness:

This chart, Exhibit 9½, contains the same information that was on the chart we had yesterday, Exhibit 9, with the exception that the curve representing the information is now drawn in a stepwise manner, to bring out the fact that in each of the periods of time involved where there is no change in the number of applications that issued into patents the line of the curve is horizontal. Beginning at the left-hand side of the chart, in the year 1886, the first patent involving the use of an acid in a well was issued, and is shown by this rise here to the level of the first step. Then from that time until about 1872, there were no more applications filed on which patents issued. In that year another one issued, carrying the level up to here (indicating). Then no more applications were filed on which patents issued until 1895, when there were two filed that became patents. That raises the level up to here (indicating). Then from 1895 to 1900, no more were filed until we get to 1900, and then there was a new one filed. That brings the level up to here (indicating). That makes a total of five in those thirty-five years. And then from 1900 to 1920 no application was filed for which we have discovered an issued U. S. patent. Thereupon one more was filed, bringing the number up to 6, and then in about 1922 another one was filed making 7, and then in 1923 or '4, another one was filed making 8. I have put the Carr application in when the continuation was filed and not when the original was filed.

The Court:

You put it in when the continued application was filed, and not when the original one was filed? A. That is correct.

The Court:

If it was put in with the original application, it would come in just over the line somewhere? A. It would come in in 1932, April 28. It would have made this kick up here a little higher, perhaps. It would have made three in here instead of two, as we have it now.

By Mr. Owen:

Q. In other words, if the original Carr application were included it would make this first vertical line to the right of the year indicated by the line 30 a little higher than it is now; is that right? A. Yes, that is right. Now, from 1929 until 1932 there weren't any applications filed on which a patent issued excluding the original of the Carr continuation which is included in this jump. The continuation is included in here and the Grebe-Sanford patent is not included inasmuch as that is one of plaintiff's, but this kick here is due to the filing of the Carr patent, 1,891,667, and a Carr-Humphrey application which issued in 1935, I believe, and I don't recall the number of it. This vertical line at the right of the line indicating the year 1930 includes the Carr continuing application which we have been considering. Even if it was with reference to the original application it would come in the same space. It would just raise this kick up, this step. This little tiny step here would be one notch higher.

The Court:

Now, as he says, as you get higher up you would arrive at the same point all the way up. It just depends whether you cross that road over to the vertical line one notch sooner or not.

By Mr. Owen:

Q. Now, will you continue from the point you left off and state the number of applications indicated in each year by each vertical line? A. Reading from the graph, the first break above the date corresponding to the filing of the Grebe-Sanford represents two more applications on which patents issued, making 12. This step indicates 15 at some date here, I think 1934. The next step indicates about 23 or 22 applications on which patents issued, up to the year 1935. And 25 applications up to 1936. Then we go to that step up here indicating a total of 40. That means there are 28—or there is 30 more than at this time here. And this point is 47, indicating 37 more. And this is 54 indicating 44 more. And that is 56 indicating 46 ap-

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plications filed up to this year 1939 on which patents issued involving the use of acid in an oil well.

Q. Referring now to Exhibit 10, please take up the patents indicated under Stream A on the left side of the chart and explain what they disclose. A. On the left-hand side of the chart there have been listed a number of references composed of patents and publications in which some knowledge is given of the use of inhibiting agents to reduce the corrosiveness of acids on iron or steel. The first entry on the list is dated 1845 and is an article appearing in the French publication, *Comptes Rendus*, by Millon, in which he reports numerous tests made of the corrosiveness of some acid solutions and the effect of the presence in that acid solution of small amounts of metals in the electro-motive series on the corrosive action of the acid. This journal apparently has been in publication for many years. I have seen a complete set of them. We have such a set in the Dow Chemical Company's Midland library. I have also seen sets of this journal in other technical libraries, and it is my understanding that it is widely disseminated in the libraries of the world where scientific and other information is kept. I would like to quote a few parts of the translation of this article:

"The impairment of metals either by pure water or by water charged with acid or saline principles is a phenomenon that occurs frequently in the laboratory. This phenomenon also concerns our domestic uses and among industrial facts it certainly has an important place."

The next paragraph goes on to state:

"The experiments that I am about to describe are all connected with this impairment of metals by water in the presence of acids or salts. They only comprise in a word a simple indication of some circumstances under whose action the common metals, iron, zinc, tin, copper are attacked and sometimes preserved but among all these circumstances there is one that I shall point out at once because I think its intervention has been almost unnoticed heretofore. I wish to call attention to the influence of small quantities."

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"This influence, if I do not mistake the first impression that I have received, is considerable. If one should say, indeed, that a little quantity of metallic solution, added in the proportion of one thousandth, of one hundred-thousandth, and often in a smaller proportion, was sufficient to increase hundred-fold the action of an acid on a metal, or to annihilate this action, or to provoke it when it did not exist, or finally even to change the nature of the products to such a point that hydrogen replaces nitrous compounds, one would seem to be, in such an assertion, as far from the facts as from chemical predictions.

"Nevertheless, that is what happens."

Those are his introductory remarks, and then he goes on to describe some of these experiments. The method of his experiments, I think, is summarized in this paragraph which I will now quote from page 2 of the translation:

"Thus, rolled zinc has been brought into the presence of dilute sulphuric acid to which has been added some traces either of platinous chloride, or of tartar emetic, arsenious acid, copper sulfate, silver sulfate, etc. The metal, weighed before the reaction, was weighed again after the reaction had lasted for a definite time. In other instances, the gas was collected and measured. I shall indicate the principal conditions of the experiments made by means of zinc and dilute sulphuric acid. The zinc was rolled in sheets thin enough to give 100 to 102 centimeters of surface per weight of 15 grams. The sulphuric acid was composed of one part of monohydrated sulphuric acid $\text{SO}_3\text{H}_2\text{O}$ to 12 parts of distilled water. The zinc was weighed exactly, and six nearly equal quantities of water were introduced into six glass flasks, each of which contained $1\frac{1}{2}$ decilitres of the one-to-twelve sulphuric acid."

The flasks were distinguished by the numbers 1, 2, 3, 4, 5 and 6. Now, I will pass over these experiments on zinc and go to those he performed on iron, inasmuch as we are here interested in iron. Here we have the essentials of his method. He weighs a zinc piece or metal piece and puts it in the acid for a given length of time, withdraws it,

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weighs again, and determines by the loss in weight what has happened. Now, the experiments on iron and tin are referred to on page 11 of the translation:

"Iron and tin have been subjected to tests analogous to those of zinc. One-to-twelve sulfuric acid dissolves iron turnings rather rapidly; some drops of platinous chloride communicate an extreme intensity to this action. Arsenious acid, on the contrary, stops all action on iron by sulfuric acid; this influence is sufficiently pronounced for the metallic iron to keep for a whole month, and without doubt still longer, in one-to-twelve sulfuric acid which dissolves it rather rapidly. When the iron is well cleaned, some drops of an aqueous solution of arsenious acid are sufficient to preserve it from the acid; at the same time it preserves metallic reflection whose shade becomes only rather darkened. Tartar emetic slackens the action of sulfuric acid on iron, but does not stop it. Mercurous chloride acts like tartar emetic. Copper sulfate accelerates strongly the evolution of hydrogen; silver sulfate also accelerates it, but less appreciably."

By accelerating the evolution of hydrogen it means that the iron test piece is dissolving at an accelerated rate.

"Hydrochloric acid receives, from small quantities of metals, the same influence as dilute sulfuric acid: these reactions can even be observed with rather concentrated hydrochloric acid; it is sufficient to dilute the pure fuming acid with 2 or 3 volumes of water. In some cases the addition of a small quantity of copper sulfate has suspended very appreciably the action of hydrochloric acid. The iron becomes covered with metallic copper and remains for several hours without furnishing hydrogen; but it has not always been thus, without it being possible to ascertain whether this difference depended on the hydrochloric acid or the iron."

These tests continue with some other acids. The next one mentioned is arsenious acid, and according to Millon arsenious acid stops all reactions as it did with the two preceding acids, the preceding being sulphuric and hydro-

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chloric. It goes on to say : "Tartaric and racemic acids are identical in all the influences that they undergo; more abundant evolution with platinous chloride; hindrance to reaction with arsenious acid; almost complete indifference on the part of other metallic solutions." I believe that that gives the essence of this part of the article.

The next reference on the chart on the left-hand side is dated 1883 consisting of a U. S. patent No. 288,150 to Benjamin F. Aiken, Jr., for wire or metal cleaning bath. This, I believe, is one of the first U. S. patents to mention the addition to a corrosive acid of something to obviate its corrosive effects, those corrosive effects being the action of the acid on iron and steel. This patent is in the pickling art, which is briefly stated to be as follows in the patent specification, page 1, column 1:

"In the successive processes of drawing wire the iron becomes fibrous and requires to be annealed to render it ductile and in the operation of annealing its surface becomes more or less covered with an oxide scale which must be removed before the operation of drawing can be continued. This is commonly done by immersing the wire in a hot bath of dilute sulfuric acid for a short time and then checking the action of the acid upon the metal or devitrolizing it by immersing the wire in a bath of hot water or subjecting it to a current of cold water, otherwise the excessive action of the acid bath would render the wire brittle and unfit to be drawn. The wire or wire rods are then coated or covered with a paste of meal or flour, clay or a solution of salt, or of lime, or of a salt and lime, either alone or in connection with oily and fatty substances which act as lubricants to the surface of the wire as it passes through the die plates."

Now, coming to his invention, he says: "I use instead of the bath of dilute sulfuric acid above mentioned a bath formed by adding to water a cleaning corrosive acid. In case the wire is to be drawn I use sulfuric acid; in other cases such as when coating with zinc or tin, hydrochloric or nitro-muriatic acid may be used and to the acid and

water I add cyanogen generally, and for convenience in the form of a metallic cyanide."

Now he goes on to say what he gains by doing that as follows: "By the combination with an acid cleaning bath of cyanogen in the form of a soluble metallic cyanide I increase the efficiency of the acid bath and effect a great saving in the cost of cleaning. I also obviate to a considerable extent the injurious results of the excessive action of the sulfuric acid bath in rendering the iron brittle arising either from the absorption of free hydrogen or from other causes."

The Court:

Is that a very good description of an inhibitor? A. Yes. For the reason that the inhibitors that we find in these patents out of the pickling art are used to correct this hydrogen embrittlement which would otherwise occur if an inhibitor was not used.

Mr. Lyon:

I would just like to have the court have in mind that this is a selection of patents which the defendant in this case has not selected, and it is a different selection from what was before the court in the Williams Brothers case.

Mr. Owen:

I want to make it clear that the purpose of this chart was not to make a complete disclosure of the prior art. We couldn't do it on a chart of this kind. But we merely selected illustrative patents or publications which would show the developments.

Witness continuing:

Now, the next one on the chart, left-hand side, is dated 1901, and is a publication called *The Journal of the Society of Chemical Industry* in which there appears an article by James T. Conroy on page 316, entitled "The Rate of Dissolution of Iron in Hydrochloric Acid." This article opens with this paragraph:

"The behavior of acids towards metals is a problem of great interest both to the chemist and the manufacturer and such behavior has been the subject of considerable investigation.

"Sometimes, perhaps most frequently, it is the manufacturer's object to obtain a metal not acted upon by some particular acid. At other times, action is desired, and in this case a knowledge of the course of the reaction, its rate and the conditions under which it occurs is of the greatest importance.

"To take a particular instance, I may refer to the cleaning of iron by acids, the so-called pickling process, a preliminary operation in the preparation of this metal for the galvanizing bath."

This article goes on with experiments performed on the rate of dissolution of iron in hydrochloric acid at different temperatures and with different concentrations of acid, hydrochloric acid being capable of many concentrations. Then when we come towards the end, in fact it is the end, he refers to the fact that the foregoing experiments were all done with distilled hydrochloric acid, practically free from impurity of any kind. (Reading):

"In practice commercially pure acid is employed. Such acid must be free from arsenic, the presence of which is prejudicial during the pickling stage apart from the trouble it causes later on in the galvanizing bath. The effect produced when arsenic is present in small quantities is shown in Table 4. When larger quantities are present the iron becomes completely covered with a film of arsenic which at ordinary temperature almost completely checks further action even with the more concentrated acids."

Now, by referring to this table, we see that the experiments were performed with hydrochloric acid of concentrations between 180 and 216 grams per liter, and with amounts of arsenious oxide of from 0.04 grams to 0.16 grams per liter and at temperatures from 18 to 61.5° C. In this experiment he measured the cubic centimeters of hydrogen evolved per hour both before arsenic had been added and after arsenic had been added, and he sets down the rate of evolution figures thus observed. To take one example out of the list, the one that appears on the chart, and converting the concentration given here in grams

per liter into weight per cent we get the following figures:

Two hundred grams per liter of hydrochloric acid is approximately a 20 per cent hydrochloric acid solution. The addition of .16 grams per liter of arsenic trioxide is approximately a 0.015 per cent solution of arsenic, and the rate of hydrogen evolution without the arsenic is given here as 26 cubic centimeters per hour, and when the arsenic is present the rate drops to 19 cubic centimeters per hour or a reduction in the rate of evolution, computed by me to be about 27 per cent.

The next one is dated 1912, an article by Oliver P. Watts, which appeared in the Transactions of the American Electrochemical Society, Volume 21, beginning on page 337, entitled, "The Effect of Various Substances on the Rate of Corrosion of Iron by Sulphuric Acid." The title is a little bit misleading, because he also works with hydrochloric. His opening paragraph is as follows: "In volume 8 of the transactions of this society C. F. Burgess called attention to the remarkable reduction in the corrosion of iron by sulphuric acid brought about by the addition of a small amount of arsenious oxide to the acid." Later he explained the protective action as follows:

"The explanation which has been offered for this phenomenon is that the iron receives by contact with the solution an extremely thin coat of arsenic which resists the action of the acid and protects the underlying metals."

He also gave experimental proof that the iron was coated with arsenic. The second paragraph states:

"It has long been known that by dipping clean iron into solutions of suitable composition and concentration thin coatings of gold, silver, platinum, copper and several other metals may be deposited on the iron. It is generally conceded that such coatings are not sufficiently continuous and impervious to protect the underlying metal from corrosion, even though the metal forming the coating may itself be thoroughly resistant to the corrosive agent. Instead of being a protection, such coatings are usually considered to be stimulators of corrosion."

We started at the place where we had an acid solution containing arsenic in the solution as arsenious chloride, presumably. There is no metallic arsenic in this solution at all. The element is there but it is not present as little bits of metallic arsenic that you could fish out. It is dissolved.

Now, this third paragraph goes on to discuss the theory of this protective action as follows: "Since all metals which thus deposit upon iron when it is immersed in a solution of the metallic salt are electro-negative to iron, a short-circuited voltaic cell is formed, of which the iron is anode and the metal deposit is the cathode. So long as any iron remains in contact with the electrolyte, it would seem, except for certain considerations which will be presented later, that the corrosion of the iron ought to be stimulated by this condition, and that the only way in which such a coating could afford good protection would be by covering the iron completely, so that no electrolyte could come in contact with it.

"Speaking of the effect of other metals in contact with iron, W. H. Walker says: 'Tin is a metal which, like copper, accelerates the corrosion of iron by aiding in the oxidation of the hydrogen set free by the reaction.' M. P. Wood calls attention to the injurious action of metals, 'The use of anti-corrosive, or anti-fouling paints, containing salts of any metal, is attended with the greatest danger to the coated (iron or steel) structure. These pigments are extremely sensitive to the presence of saline elements in moisture, their action being to rapidly dissolve portions of the iron, and to deposit the metal which they contain upon the surface of the plates, and these deposits, exciting energetic galvanic action, cause corrosion and pitting to go on with alarming rapidity. Both mercury and copper salts are offenders in this way.' "

I am going to read directly from paragraph 2 on page 338. (Reading): "It appears then, that arsenic is unique among the metals which precipitate themselves upon iron from solution, for arsenic protects iron almost completely

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from powerful corrosive agents, while the other metals are generally considered to aggravate corrosion and rusting.

"If the coating of arsenic is so porous and imperfect as the action of acids show the coating of copper, for example, to be, how can the arsenic protect the iron any better than copper does? It occurred to the writer that the explanation lay in a high over-voltage or excess potential of hydrogen on arsenic, and the experiments which follow were undertaken to discover whether this is the explanation of the singular and mysterious protective action of arsenic. If the above explanation is correct, among the metals which deposit upon iron when it is immersed in a solution of their salts those having a high over-voltage for hydrogen should protect iron, and those of very low over-voltage should aggravate the corrosion."

The Court:

Does that mean that silver and copper, and those other things that he mentions actually tend to corrode, destroy iron when they are present, worse than if they are not present? A. Yes.

The article goes into the matter of the electrode potentials of the metals involved here, that is the voltage assumed by the metal with respect to the solution in which it is immersed, and he gives a table of what is called single potentials of many of the metals in the electromotive force series of metals between iron and mercury, and including those metals. Then he goes on with his theory as follows:

"On the theory that the protection of iron by a deposit of arsenic is due to the high overvoltage of hydrogen on the latter, the action would be as follows: Iron dissolves and by so doing deposits arsenic upon the surface of the iron. Since the arsenic is deposited simultaneously with the dissolving of the iron and only as a result of this dissolving it is hardly possible that the iron should be completely covered by arsenic, but here and there holes will exist allowing the iron to make contact with the electrolyte. Voltaic cells are thus formed."

The Court:

Is this chap right in his theory? A. I subscribe to this theory. (Continuing reading): "The iron is anode and the arsenic cathode, and just as in any other primary cell with sulfuric acid as electrolyte, hydrogen is deposited on the cathode, but when hydrogen is liberated on arsenic the potential of the latter is raised 0.39 volts higher than 0.277, the potential at which hydrogen is liberated on platinum black. This would raise the potential of the arsenic to +0.113 volts or higher than the potential of the iron anode. This means that in our iron-arsenic cell there can be no visible evolution of hydrogen on the arsenic for before this can occur the potential of the cathode has become equal to that of the anode and corrosion of the iron ceases. In other words, this particular primary cell polarizes so badly that after a few seconds of action its electromotive force has fallen to zero."

Then he goes on to say (reading): "If the above explanation is correct, protection should be afforded by those metals which plate out on iron by immersion, and whose over-voltage for hydrogen is great enough to raise their potentials to at least equal the single potential of iron. The potentials of the following metals are far enough below that of iron to expect that they will deposit on iron even in moderately strong sulphuric acid."

By Mr. Owen:

Q. In this Watts article, I notice that on page 352 he gives a table under several headings: One of them is "Retarders of Corrosion," and another on page 352 is "Accelerators of Corrosion." Now, I would like to have you state to the court which metals are contained under each of these headings, first under the heading of "Retarders of Corrosion." A. The first here is arsenate of sodium. Of course, that is not a metal but it is a compound containing the metal which he used. Arsenic sulphate, chloride of manganese, chloride of mercury, chloride of sodium, chloride of tin, chrome alum, chromium sulphate, mercuric chloride, mercuric sulphate, and stannate of sodium. Stannate of sodium is a tin compound.

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Under the heading "Accelerators of Corrosion" the first in order is bismuth sulphate. Then chromium chloride, copper sulphate, gold chloride, mercurous nitrate, platinum chloride, potassium chlorate, chromate, dichromate, nitrate, permanganate.

The next reference on the chart, Exhibit 10, is a publication from the Bureau of Mines, Department of the Interior, dated October, 1919, entitled "Substitution of Nitre Cake for Sulphuric Acid in Pickling Steel," by E. E. Corbett, Chemical Engineer, U. S. Bureau of Mines.

On page 2, under the heading of "Mechanism of Pickling Reactions," it states (reading): "The free acid in hot, dilute solution attacks the metal very readily, etching it away from beneath the coating of scale and consequently throwing off the particles of oxide from the surface. Iron goes into solution as ferrous sulphate; and the hydrogen which is liberated at the face of the metal is carried rapidly to the surface of the solution, where it escapes into the air with the steam and other gases rising from the pickling bath. • • •"

Now, the portion of this publication which is of interest in this connection here is that part beginning on page 5 under the heading of: "Inhibition, or moderation of metal attack," as follows:

"The activity of the acid, then, is directed to attacking selectively and dissolving the sound metal rather than the more resistant oxide or scale; but in well regulated pickling practice the selective attack is limited, and, indeed, materially re-directed and controlled by the use of bodies of a colloidal or semi-colloidal nature whose influence serves to protect the metal during scale removal. These bodies are for the most part of vegetable origin, and comprise various wood sugars and gums, and cereal starches and intermediates occurring in commercial grain milling."

And then he goes on to mention other types of inhibiting agents as follows: "Tin and copper salts are representatives of the inorganic type of semi-colloidal inhibitors; but their action is of inferior consequence and their use re-

stricted because of the cost of adding to the bath quantities sufficiently large to exercise a sensible influence, as well as their tendency, undesirable for most purposes, to plate out from solution upon the metallic surface."

Mr. Lyon:

I would like to ask a question before we leave this Corbett article. Was this article ever published? If so, where, or from where, by whom, and when? A. I can refer to an article which appeared subsequently to this as a result of the issuance of this article by Mr. Corbett in the *Automotive Industries* for 1918, December 5. This article was almost re-written word for word in that publication, which, of course, has wide circulation in the metal trades.

The next reference under Stream A of Exhibit 10 is dated 1921. It is the British patent No. 158,768, having a complete accepted date of February 17, 1921, for improvements in pickling iron or steel. This patent is apparently the counterpart, or the British application corresponding in many particulars to one filed in this country in the name of Vogel, so I have put the name Vogel against this British patent. This teaches about the corrosive action of the acid during the pickling operation, and some of the evil effects resulting from that, and proposes the addition to the pickling bath of certain substances to overcome those difficulties.

Quoting from the specification, page 2, column 2, beginning with line 73, it reads as follows:

"A modification of the process consists in adding to the pickling liquor, not the protective substance itself but a suitable extract thereof. It has been found that it is not the main constituent of the substance in question, namely, anthracene, naphthalene, phenol or the like, that has a particularly good effect, but other constituents the chemical constitution of which has not been elucidated, but which nearly always accompany the main constituent. The active substance may be extracted by inorganic acids, neutral or acid salts, organic solvents such as hydrocarbons (petroleum, tar oil). Advantageously the parent substance may

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be treated with 3 to 4 parts of sulphuric acid of strength which may vary, or of hydrochloric acid or of other suitable extracting agent and, according to its strength, 1 to 10 per cent of the extract may be added to the pickling liquor.

"There is added to the liquor a quite small proportion of a material which causes formation of the thin protective layer. For forming such a layer, having regard to sufficiency of supply and cost, the following has been proved particularly suitable additions:—Crude anthracene, sulphite lye, residues from the production of naphthalene and the like."

There are some other substances mentioned which might be used. "There may also be used either alone or in addition to the said parent substance the waste acid from the refining of mineral oil, ground coal tar oil, coal tar oil, paraffin wax, and the like, or acid resins, or distillation residues of organic compounds of any kind, particularly residues in which pyrogenic decomposition has occurred."

By Mr. Owen:

Q. In this British patent, is mention made of any particular acid in which these inhibiting substances may be used in connection with the pickling bath? A. There is the mention of a dilute mineral acid, for instance hydrochloric acid of 22 Baume specific gravity used, or sulphuric acid of 10 to 12 Baume specific gravity, frequently mixed with a solution of sodium sulphate.

The last patent is dated 1928, No. 1,678,775, to James H. Gravell. This patent discloses the use of metals in an acid solution, the same metals that we have previously seen and which have been referred to in some of these prior articles, including the Watt article, for the purpose of putting a protective coating on iron and steel containers, so that the action of the acid on the containers would be prevented. And these metallic inhibitors may be used in that process with and without the presence of what are here called pickling control substances or acid regulators.

The acids which are supposed to be rendered non-corrosive by the presence of these added metallic elements are

any of those acids commonly or normally corrosive to iron or steel, and because of that corrosiveness would have to be carried in glass or specially lined containers.

Q. According to this patent, what metals are supposed to have that protective action? A. The patentee states that "The metals which have that property are below iron and above mercury in the electro-motive scale." Some of the common metals that lie in that range of the series are cadmium, nickel, lead, tin, arsenic, antimony, bismuth, thallium and copper.

CROSS EXAMINATION

By Mr. Lyon:

Q. In connection with the selection of those patents didn't anybody suggest or refer to the list of patents appearing at the bottom of page 496 of 81 Federal Reporter, Second Series, the particular patents that were referred to by Judge McDermott as showing inhibitors? A. I don't recall whether they looked at that or not.

Q. You didn't hear any discussion about whether you better put on this Stream A the same patents that Judge McDermott set forth in his opinion, or whether you better put different ones in? A. I do not recall anything like that. I am practically certain there was no mention of that.

Q. What is supposed to be represented here by the graphical illustration extending from Gravell's patent in 1928 down to this block in which appears the words "Grebe and Sanford"? That there are no patents between the Gravell patent and Grebe and Sanford's patent relating to the addition of inhibitors to hydrochloric acid? A. No, it doesn't mean that. I don't recall what ones intervene in that period. I don't remember how many there were in that thing. It seems to me there were quite a number of patents in this art of pickling and its related arts, but their pertinency—it doesn't add anything to these things that are already there such as there were where,—I believe they were left off for that reason.

In my search of the prior art and the investigation that I made of patents and the literature references prior to the Gravell patent, I found reference to shipping hydrochloric acid in a steel container or drum, protecting the drum or container by the use of an inhibitor. Those references are not on this chart. These are simply in connection with the prior state of the art for Grebe and Sanford.

There is a reference by an author named Fawcett in the *Journal of the Society of Chemical Industry of London* in which he discloses the use of arsenic to be added to sulphuric acid and for the shipping of that acid in an iron drum so that the drum would not be attacked. This article is entitled "Action of Concentrated Sulphuric Acid on Iron."

Q. Did you find anything in this Fawcett article that refers to shipping hydrochloric acid in steel containers? A. I don't believe there is mention of that.

Q. Well, now, have you found any other, is there any reference that you have found that you have omitted from Stream A prior to the Gravell patent which suggests shipping hydrochloric acid in a steel container and protecting the container by an inhibitor? A. I believe there is another one. The patent to which I refer is No. 1,608,622, filed September 30, 1925, for process for preventing the dissolution of iron and steel in sulphuric acid and pickling baths.

Q. In connection with arranging your curve on Exhibit 9-A, we discussed the Carr patent. I hand you a certified copy of the file wrapper of the Carr patent as it issued, No. 1,891,667, and the parent application filed April 28, 1932. Have you ever read either the original application or the Carr application, upon which the Carr patent was issued? A. I may have, but I have forgotten now.

Mr. Lyon:

I would like to offer, Your Honor, so that we can have it for future discussion, these two certified file wrappers; the first being the file wrapper upon which the patent was issued, No. 1,891,667; and the second, the file wrapper of the earlier application.

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The Court:

Let us call the first one that you marked DX-11, and the other will be DX-11½.

(The documents in question were thereupon marked Exhibits DX-11 and 11½.)

Q. Now, who made the decision in connection with what was to be incorporated on the curve of Exhibit 9-A, that this Carr patent should not go on the curve, or, should not go on until after you have indicated that the Grebe and Sanford invention had come into existence? A. I decided that.

Q. Who? A. I decided that.

Q. Did you discuss that with counsel for the plaintiff here, who are appearing in this case? A. Yes, I discussed that.

Q. On what basis did you make that decision? A. Let me see. The decision to put these patents on was based upon the filing dates, and I assumed that that would fairly represent the date of invention of these patents, in the absence of other knowledge on the subject.

Q. Then you did not actually go into the question, the factual question of which of these inventions was earlier? A. That is right. I am not advised as to that.

Q. You know, do you not, that the Dow Company, the plaintiff in this case, holds the rights under this Carr patent, and the invention of Mr. Carr? A. I do not know what you mean by that.

Q. You don't know what I mean by that? Don't you know that the Dow Company is licensed under this Carr patent and Carr invention? A. Yes; they have a license.

Q. You know that the Dow Company pays a \$5.00 royalty for each and every acidizing job that it does to Pure Oil Company under these patents, do you not? A. That is what I have been told.

Q. Well, now, you did not go in to find out whether the Carr invention was ahead of the Grebe and Sanford invention? A. Not in constructing this chart, no.

Q. Did you have anything to do with the preparation

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of the application upon which the Grebe and Sanford patent No. 1,877,504 was issued? A. No.

Q. That was not any—you did not have anything to do with that? A. No, I did not.

Q. You don't know whether or not as originally prepared that application prescribed that the use of inhibiting acid was unnecessary, or the use of an inhibitor in the acid was unnecessary? A. I had no part in the preparation of that application.

By Mr. Lyon:

Q. Referring now to this Exhibit 9-A, the curve, can you give us a list of the patents and other references that are embodied in this curve subsequent to the point on the curve to which the arrow refers, and with a statement as to what they are about? A. The Carr patent 1,891,867 filed June 30, 1932, was a method for facilitating the flow of wells and, briefly, it consists in loading the well hole with oil so as to confine the acid subsequently introduced to the lower levels of the well to prevent the acid from rising in the casing.

DeGroote, 1,922,154, filed January 9, 1933, proposes to emulsify acid in an encasement of oil before putting it in the well so that it won't corrode the pipe.

MacMillan, 1,969,230, filed February, 1933, loads the well with oil to force the acid into the producing formation.

Weir et al, 1,984,668, filed March 10, 1934, is for demudding the walls of the well hole with acid when the mud has previously been treated with calcium carbonate so it will have an acid soluble constituent in it.

Wilson, 1,990,969, filed March, 1933, is for acidizing an oil producing formation, the acid for the purpose being generated in situ by the reaction of a solution of hydrochloric acid and a soluble fluoride.

Ambrose et al, 1,999,146, filed June, 1934, for a method of increasing the production of wells proposes to employ chlorine gas in the well hole, the gas reacting with water therein to generate an acid.

Mills, 2,001,350, filed 1934, proposes to introduce into

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the well and into the producing formation in succession alkali, then an oil spacer, then acid, and repeating that over and over, thereby forcing out into the surrounding formation concentric rings of acid and alkali which eventually mingle with each other and generate heat in the formation, or otherwise do something there.

Muscatt 2,010,409, filed 1934, is for producing a plugging deposit in water-bearing formations, which might be adjacent to the oil producing formation or even in the same formation, and he reacts therein sulphurous acid and hydrogen sulphide, thereby getting a precipitate of sulphur in the pores.

Carr, et al., 2,018,199, filed October, 1932, is for balanced pressure method for introducing acid reagents into oil wells and it consists in introducing inhibited acid, that is, acid containing arsenic acid, into the oil well after it has been allowed to fill with the produced fluid of the well.

Muscatt, 2,016,118, filed 1935, is for method of selective shutting off of water flow in oil wells, and consists in injecting sulphur mono-chloride into the well under heavy pressure so that it enters and passes outward through the pores of the wet formations, the sulphur mono-chloride hydrolyzes in the earth formation, thereby depositing free sulphur, and, of course, along with that reaction there is produced hydrochloric acid.

Woods, 2,030,777, copy of which I do not have here, is about drilling a well in an acid-soluble formation with conventional rotary tools, and in place of circulating drilling mud through the tools while the drill is in operation, he would use hydrochloric acid.

Pitzer, 2,035,719, filed in 1935, is for method of treating oil and gas wells and he proposes to introduce into the cavity at the base of the well what he calls an inert crushed treatment material of a particular size or mesh, namely 1 to 1½" mesh, and he may thereupon treat the well with acid or alkalis or other chemicals.

DeGroot, 2,038,720, filed 1936, is for process for increasing productivity of wells and it consists in emulsify-

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ing two different reagents, introducing them into the well and allowing these emulsions to mingle and produce a reactive agent in the well, which is forced into the formation.

Parkhurst, 2,038,956, assigned to the Standard Oil Company, filed in 1934, is for the acid treatment of an oil well, the title being "Well Treating," and it consists in introducing the acid solution into the well and then a charge of an aqueous solution of caustic soda.

DeGroote, assigned to Tretolite Company "Process for Increasing the Productivity of Wells," No. 2,045,759, is similar to the other ones where he employs an emulsified acid for acid treating in the producing formation.

Davis, 2,045,899, filed April, 1935, is for method of increasing production from wells, and it discloses to use acetic acid for the purpose, the acid being injected into the producing formation.

Saukatis, filed 1934, 2,049,517, discloses to treat wells by introducing into them an inhibited acid solution, the inhibiting agent being a combination of copper and any one of dozens of organic chemicals which themselves have an inhibiting action.

DeGroote, 2,050,931, filed 1936, is for "Preliminary procedure for conditioning wells," after which he discloses that they may be treated with hydrochloric acid.

DeGroote, 2,050,932, filed in 1936, employs an emulsified acid solution for treating the well, there being present what he calls a dormant de-emulsifier so that this emulsion will not break too soon.

DeGroote, 2,050,933, filed February, 1936, refers to his earlier patents on the use of an acid in an oil well, and this one is for a modification of that type of process employing an emulsified hydrochloric acid as the treating medium.

Hund, et al., 2,059,459, filed June, 1936, proposes to employ a non-aqueous acid solution, the acid becoming active upon dilution with water in the producing formation.

Pitzer, 2,080,875, filed March, 1936, for method of and means of treating wells, discloses the idea of exploding a cartridge in the well bore beside the producing formation,

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the cartridge walls being loaded with projectiles, and the container cartridge may also contain chemicals, and when this cartridge explodes, it forces these projectiles and the acids, or whatever it is, in the container, into the side walls of the well hole.

Vandergriff, 2,094,479, filed December, 1936, for treatment of wells, consists in injecting into the producing formation a mixed acid solution containing hydrochloric acid and hydrofluoric acid.

Lang, 2,107,007, filed in 1936, discloses in connection with a process entitled "Method for increasing the recovery from oil sands," the use of an acid solution for increasing the permeability of the formation surrounding an input well; that is a well, I understand, that is used for repessuring operations. The particular feature about this process is the mechanical treatment of the well bore before the acid is used.

Clason, 2,122,452, filed 1936, is for acid treatment of wells wherein he has a special way of blanketing off certain formations with a blanketing medium and acidizing the other portions.

Menaul, 2,122,483, filed January 11, 1937, is for "method and means for acidizing wells" wherein there is first put into the well hole what he calls a non-jellifying material in admixture with calcium chloride solution ahead of the acid.

Miller, 2,124,495, filed April, 1936, is for treatment of drilled holes and consists in using hydrochloric acid to de mud well hole when the mud contains calcium carbonate. It is distinguished, however, from that Weir et al. patent previously mentioned by me in that in this case the carbonate used is a solid powdered form, whereas in the Weir et al. it might be an aqueous solution of the carbonate. I believe I might have wrongly stated the nature of the carbonate used in that Weir et al. patent as being solid, and I think it is really a solution that is used.

Loomis et al., 2,124,530, assigned to Shell Development Company, filed 1936, is for "method of treating wells," and

it makes use of water insoluble organic solvents in combination with aqueous acids.

Morgan, 2,128,160, filed 1937, is for well treating fluid consisting of an acid solution containing gelatin or what he calls a protective colloid capable of maintaining the mud present in an oil well in a suspended and dispersed condition in the presence of strong acids.

Morgan, 2,128,161, filed July, 1938, is for well treating fluid, this fluid consisting of an acid solution containing what he calls a calcium sequestering agent.

Bresler, 2,140,183, filed July, 1936, is for method of treating wells, and he uses an acid solution containing barium chloride.

Savits, 2,143,251, filed June 1938, is for method of and equipment for acidizing wells, and discloses a special device in combination with a packer and tube for acidizing independently more than one formation in the same well.

Averson, 2,148,006, assigned to Standard Oil Company, filed October, 1938, is for acidizing a well with sulfamic acid.

Menaul, 2,149,617, filed December, 1936, is for method and apparatus for handling acidic solutions and it discloses that by electrically coupling metallic lead to the tubing of an oil well through which acid is to pass in acidizing the well the tubing will be protected from corrosion.

Owsley, 2,163,449, filed 1938, is for method of treating a well. The use of acid in connection with this has to do with opening up a water stratum into which cement is to be injected so that the cement will enter. Thereafter the water will be shut off, as I understand that.

Lee, 2,171,416, for method of treating a producing formation involves the making of superimposed lateral channels from a well hole and acidizing these channels independently.

Herbsman, 2,172,083, is for method of treating inorganic mineral slimes in oil wells, filed May, 1937, which comprises forming an aqueous suspension of a sulfonated glyceride and introducing the suspension into that portion

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of a well in which there are accumulations of slime. The specification states that in treating a slime of the carbonate type, the treating agent is produced by forming a suspension of sulfonated glyceride with an aqueous acid solution. The acids usually used in this solution are hydrochloric acid or acetic acid.

Loomis, et al., 2,177,345, assigned to the Shell Development Company, filed 1938, is for method of treating wells. This consists in employing an acid solution to which acetone has been added, or the like.

Simmons, 2,186,349, filed January, 1937, is for method of acidizing wells, the feature about this being mechanical means and methods for locating the acid where desired in the well hole.

Pitzer reissue 21,356, application for reissue February, 1938. This discloses the same invention as in the previous Pitzer patent, bearing original number 2,080,865.

Robinson, Jr., assigned to the Texas Company, 2,198,563, filed June, 1937. In connection with his process, called "Method of Completing Wells," in which a drilling mud fluid may be used as the circulating medium, and may contain calcium carbonate, he employs an acid solution for disintegrating the mud after the well has been drilled.

DeGroote, 2,204,580, application February 17, 1936, assigned to The Dow Chemical Company, is for acidizing a well with an acid solution containing a preferential wetting agent comprising an alkylated sulpho-aromatic acid.

Herbsman, 2,206,187, filed June, 1937, for "Method of Increasing Production of Oil Wells," consists in introducing a solution of hydrochloric acid gas absorbed in a liquid, which is immiscible with water in the well, a liquid such as oil.

Holmes, 2,224,297, filed April, 1939, for treatment of oil wells, consists in employing a strong acid with salts.

Carr, 2,237,131, assigned to Pure Oil Company, filed December, 1938, for treatment of wells, consists in a process of drilling involving the use of an acid solution not as an aid to the drilling but in certain stages of the drilling,

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for the purpose of increasing the porosity of the formations being drilled.

Zacher, 2,234,790, filed February, 1939, for mud wall disintegrator, discloses the use of a weak acid to which a salt of a strong acid has been added for cleaning off the mud from the walls of a well hole.

Mr. Owen:

I would like to ask a question now. In this list of patents you have just read I notice that at least one patent was included which was assigned to The Dow Chemical Company. Will you explain again, in that connection, just what it is you have omitted from that graph with reference to Dow Chemical Company inventions? A. I omitted applications that were of Dow inventors, but I included that DeGroote application, although it was owned by Dow, but we didn't come to own it until some time after it had been filed in the Patent Office.

Q. So that this list does not include any inventions or any patent to inventors who were employees of The Dow Chemical Company subsequent to the Grebe and Sanford patent? A. Yes, sir.

Q. Were any Dow applications omitted which were filed prior to the application for the Grebe and Sanford patent? A. Yes.

Q. Then this graph does not include any patents issued on applications of Dow Company inventors other than the Grebe-Sanford? A. It does not include that one. I haven't included any Dow inventors' applications on which a patent issued.

Q. Then the Grebe-Sanford application on the chart and the arrow pointing to one of the angles is merely to indicate the point where the Grebe-Sanford application would have come had it been included? A. That is correct.

Q. Could you state how many applications filed by Dow Company inventors there are which would have been properly included in this chart had you wanted to make it complete so as to cover all applications? A. The number of applications which have now matured into patents,

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the same as the ones I have spoken of, except for ownership, I think there are 28, or thereabouts.

By Mr. Lyon:

Q. This list that you read in answer to my previous question, of the patent applications that are embodied in the curve Exhibit 9½, subsequent to 1932, included many relating to inventions that were not actually on acidizing wells; they relate to various other inventions which involve in some way the use of acid down a well, rather than acidizing inventions? A. That is correct.

Mr. Owen:

That applies also to the part of the chart previous to Grebe and Sanford? A. Yes.

By Mr. Lyon:

Q. Now, it will only take a minute just to complete this information about this curve, if you have it there, so I am going to ask you to identify the particular patents that are responsible for these steps on the curve prior to 1932. You have done that partially, but in looking through the record, I could not make it add up. A. The first kick up is due to the Sherwood patent, No. 57,982, and in that connection I should state that I have assumed that the issue date of Sherwood is the same as the filing date because I did not have any means to determine the date on which it was filed. It does not appear on the copy of the patent. Then the next kick up is due to the addition to that of the Looney patent application, which became patent No. 139,010. The next is due to the two patents issued on applications filed in 1895, the first is Van Dyke, 556,651, and the second Frasch, 556,669. The next rise is due to the Ball patent application which matured into patent 670,577. The next is Muehl, filed in 1920, and issued into 1,410,827. The next is Tilton filed in 1922 issued into 1,608,869. The next is Lake and Phelps, filed 1923, becoming patent No. 1,498,045. The next is Ranney filed 1928, issued as 1,806,499, and the next is Bowman, filed 1929, and issued as 1,809,546.

I did not embody or include in my curve the patent to DeGroote, 1,892,205, of December 27, 1932. I am not especially familiar with that patent.

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Q. Well, I think if you look at it you can see quite quickly that it relates to a solution which is put down an oil well to prevent the accumulation of solid matter, and it gives a review of the prior patents of the Tretolite Company on that same subject. They are listed on page 2, the patent to Brady and the patent to Campbell. Are you familiar with those patents? A. I have seen those patent copies, I am pretty sure.

Q. Well, will you tell me why those are not properly included within the list of solvents, chemical solvents employed to aid in a producing well? A. I would have to take a look at that again, but my collections from which this is drawn have been classified to include such patents as involve the use of acid in a well, and since I did not find any others in my group I haven't put them on the chart. I therefore have assumed that my chart completely represents patents that involve the use of an acid, and that these therefore did not.

I considered in connection with the preparation of my charts the Ackerman patent 1,734,990, granted November 12, 1929, and I hand you a copy of that. It mentions sulphuric acid, but it doesn't come under my classification. It discloses a composition of matter which, as Mr. Lyon states, is for the purpose of preventing pipe lines from becoming clogged, and this composition of matter is made up of the following ingredients: Anthracene, $3\frac{1}{4}$ per cent, sulphuric acid, concentrated—that is 93 per cent concentrated—0.65 per cent, oil of mirbane, or nitrobenzene, 1.3 per cent, naphthalene flake, 66 per cent, sodium hydroxide granular or powder, 28.8 per cent. Upon forming this composition of matter, the sulphuric acid originally present becomes sodium sulphate and the mixture is no longer an acid solution and it, therefore, does not come under this classification.

I am familiar with the patent to Walker, No. 1,873,082, granted August 23rd, 1932, on an application filed October 30th, 1926, and have it in my collection and have read it. It is my recollection about this that it does not disclose putting acid into a well. Perhaps I have overlooked it, but that was my recollection.

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By Mr. Lyon:

Q. The patent refers, does it not, to a method of treating oil wells by lowering fluid, for introducing a fluid into the well to remove scale (handing patent to witness). I think that is what the patent is about. A. The first claim in the patent reads as follows:

"The method of treating oil well liquids to render them non-corrosive and non-scale forming which comprises adding to the well liquids a reagent comprising mixture of an alkali metal salt and a caustic alkali solution of tannin in amounts sufficient to cause precipitation of the insoluble alkaline earth salts upon the well liquids in a pulverulent and non-scale building form."

That, of course, is not an acid solution. It refers to a number of acid substances, but, of course, they are not used as such in this process. It used salts of those acids rather than the acids themselves, and I excluded the patent on that understanding.

I have seen patent 1,804,078 granted to Martin William Baden of Winfield, Kansas, on May 5, 1931, on an application filed November 26, 1928. It was not considered by me at the time I compounded the data for that curve.

Mr. Owen:

I offer books of patents in connection with Charts 9, 9 $\frac{1}{2}$ and 10. Call the book with reference to 9 and 9 $\frac{1}{2}$, PX-9 $\frac{3}{4}$, and the one with reference to 10 call it PX-10 $\frac{1}{2}$.

Donald D. Hall

DONALD D. HALL,

a witness called by plaintiff, testified as follows:

DIRECT EXAMINATION

I reside at Midland, Michigan, and am superintendent of the Chlor-benzol plant for The Dow Chemical Company. I have worked for The Dow Chemical Company since 1923.

I am a chemical engineer, graduating from Case School of Applied Science in 1921, and I worked in the intervening time for The Standard Oil Company in Cleveland, Ohio. When I first was employed by The Dow Chemical Company I worked in the salicylates division, doing laboratory work on pharmaceutical products. It is aspirin and those products. Thereafter the Chlor-benzol plant was started up and we did some laboratory work as this plant was being started, and I worked into the superintendency of that particular plant. The primary product of that plant is monochlor-benzol. Hydrochloric acid is a by-product. There is considerable use within the Dow plant for hydrochloric acid, and that took care of quite a large part of it, and about 1931 we began to ship it to customer accounts. We had only a few customers to begin with and first we only had one car, a rubber-lined tank car, 8,000 gallons, in which we shipped the acid; then it gradually developed from that point. The hydrochloric acid is manufactured in standard commercial strengths of 18 Baume, 20 Baume, 22 Baume, and recently we have a stronger acid. Prior to 1932 we shipped it in standard commercial strengths. As this acidizing of wells developed we began to supply that acid in 15% strength.

I have our record of shipments of hydrochloric acid for the year 1932 with me. The first shipment I find in our record reads as follows, it is the second shipment of the month, dated February 11, Order No. 38,118, to the Pure Oil Company of Mt. Pleasant, Michigan, of one wagon of

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15 per cent HCl, 790 pounds 100 per cent HCl. That was on February 11, 1932. I don't know what particular well that went to.

By Mr. Owen:

Q. Was anything placed in that 15 per cent acid before it was shipped on the occasion to which you have referred?

Mr. Lyon:

Well, I don't think the witness has laid any foundation for that answer. As far as I know he has only identified this book. He hasn't stated that he manufactured the acid or remembers the transaction. Maybe he does, but I think your foundation should be laid.

Mr. Owen:

He stated he was in charge of the Chlor-benzol plant of the Dow Chemical Company.

The Court:

I will let him answer. You can cross examine him and see how far wrong he has gone in saying he knows. I will let him answer. A. Yes. We secured arsenic acid. We obtained that in a two gallon glass bottle from the lead arsenate plant and put it in that shipment. That is another plant within the Dow organization. I personally know that that two gallons of arsenic acid was placed in this 500 gallon shipment of 15 per cent hydrochloric acid. I did not do it myself, but I secured the acid. I had to use the telephone to secure the arsenic acid and have it delivered and gave the orders to the men to put it in. I can't say that I saw it put in but I am satisfied it went in that shipment.

The Court:

Did you put it in so it wouldn't eat up the tank that carried it? That is the purpose of it? A. Yes. I presume that is the purpose.

Mr. Owen:

Q. Do you recall what kind of a tank that acid was placed in at your plant? A. I think that first one was a wooden tank wagon that was placed on a truck; rather, this whole thing was gotten together rather hurriedly in order to get it to the field as quickly as possible.

The Court:

Then, it wouldn't be for the protection of the tank?

Mr. Owen:

No, it would not. It was for the protection of the tubing in the well.

The Court:

In the well?

Mr. Owen:

Yes.

The next shipment I find in my record of 15 per cent hydrochloric acid was made March 11, 1932. It was virtually a duplication of the previous shipment, 500 gallons of 15 per cent acid. Two gallons of arsenic acid. The next shipment was on April 5, 1932. That was 15 per cent acid with the two gallons of arsenic acid. 500 gallons of acid. And the next shipment was April 27th. Those were all in the same amount. Each shipment contained two gallons of arsenic acid. Those shipments were all made to the Pure Oil Company. Other shipments were made to the Pure Oil Company on May 5th, 21st, 25th, 27th, 28th, and 31st. Those shipments all were the same as the previous ones, 500 gallons of the 15 per cent hydrochloric acid, and containing 2 gallons of arsenic acid. In the first half of June there were about eight shipments, that is, June 1, 3, 4—there were two on the 4th—on the 7th, 9th, 11th, 13th and 15th. Those were all of the same amounts of acid and in each case the acid contained the two gallons of arsenic acid. Four of those were made to the Pure Oil Company, and four to miscellaneous other companies, three to the Columbia Oil & Gas Company, and two to Lawrence Lee.

The Court:

Can you give me some idea as to how much of this was used in acidizing a well? A. Well, they would sometimes come in for a second load to put in the same well. I think originally they only used about one 500-gallon treatment, but later on they began ordering larger amounts. I cannot answer as to the practice in the field.

Donald D. Hall

The Court:

But you think they used at least the one 500-gallon tank in a well?

Mr. Owen:

That is the fact, Your Honor; and now the treatments run up, I understand, as high as 10,000 gallons for one treatment. They started in with 500 gallon treatments.

The Witness:

During the last half of June, 1932, there were 23 shipments of this 15 per cent hydrochloric acid, part of them to the Pure Oil Company, and the others to miscellaneous users. Others than the Pure Oil Company receiving those shipments were The Chippewa Oil & Gas Company, the Mt. Pleasant Oil & Gas Company, W. L. McClanahan, Lawrence Lee, the Talbot Oil Company, the Gordon Oil Company, the Storkwell Oil Company, the Michigan Gas & Oil Company, the Luther Drilling Company and Ohio Producers & Refining Company, the balance being for the Pure Oil Company. Some of those shipments were for 1,000 gallons instead of 500 gallons. In the thousand gallon shipments, four gallons of arsenic acid were put in.

During July, 1932, 51 shipments of this 15 per cent acid were made. Those were either for 500 gallons or 1000 gallons of this 15 per cent hydrochloric acid, with the proportionate amount of arsenic acid.

Q. Will you name the different companies or individuals to whom those shipments were made during July, 1932?

Mr. Lyon:

I might suggest if counsel had some kind of a schedule of this, or table of it, or some summary, we don't contest the shipments at that date after the filing of this application, and you can put it in much quicker than calling the witness.

Mr. Owen:

We have such a summary made up which the witness is testifying from.

The Court:

You can call it an exhibit, and I will admit it.

Donald D. Hall

Mr. Owen:

I will offer that summary, then. It goes up to and including November 10, 1932, which was the date when Dowell, Incorporated, was organized and took over the business.

Mr. Lyon:

You say it is a correct summary, or if you say the witness will testify it is a correct summary, why, we will receive it as such without any argument about it, Your Honor.

Mr. Owen:

We will ask the witness about this.

By Mr. Owen, continuing:

Q. Is this a correct summary of the entries in your original book of entries for that period? A. It is essentially correct. There may be one minor typographical error, of which I am not familiar.

Q. At least you haven't put any entries on this summary that are not in the book? A. To the best of my knowledge it is correct.

Mr. Owen:

I will offer that as Exhibit 12.

(The summary above referred to was thereupon marked PX-12.)

CROSS-EXAMINATION

The order number for this shipment which was made on February 11, 1932, and which I state was the first shipment of 15 per cent hydrochloric acid made by the Dow Company was No. 38118. The shipment record reads: "Product: Hydrochloric acid. Month of February, 1932," and shows only seven orders during that month. It was the only one of those orders showing 15 per cent hydrochloric acid. Independent, down below all these entries, is written in there 2 gals. arsenic, Pure Oil. Relative to the making of these seven entries, that was put on there at the same time or at the end of the month. In a later case, we had a trans-

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fer between the lead arsenic plant and the Chlor-Benzol plant of our arsenic acid. We got it in two gallon glass bottles, and we had to account for that, and we put it in our inventory which had to be turned into the accounting department. It was credited to the lead arsenate plant and charged to our plant. I can't say whether it was charged to the Pure Oil Company. The Sales Department would bill the Pure Oil Company either for the acid, the arsenic acid, or for the combination, and I don't know how it was handled. I think this entry, 2 gals. arsenic acid, Pure Oil, is my handwriting. Most of these,—quite a number of these are my handwriting, but they are not all my handwriting. Mr. Reid made several notations. This is my writing. Here is Mr. Reid's writing here. I think I put this notation on this particular sheet at the end of the month, but I am not absolutely sure. I have had this shipment record in the file in my office since 1932.

The records of which you show me photostats for the month of June and the month of July, 1932, are abstracts. We have no other shipping record of these shipments than the book I have produced. What you have shown me are abstracts. This is the original shipping record right here. Mr. Lyon:

Q. That does not seem to be the same either, because you can't identify these sheets that I have shown you the photostats of? A. They are not taken directly from this record. They appear to be an abstract of this record. The order numbers are the same, but they have omitted, I think, shipments such as some of our commercial shipments of 18 and 22 Baume acid.

Q. Now let's go back to the February 1932 shipping record, your original shipping record. In what form did you receive instructions to make the shipment to the Pure Oil Company February 11, 1932? I notice your shipping record shows order #38118. A. That is the regular Sales Department order. I received such an order from the Sales Department.

Q. Was it specified on that order that you should

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also ship some arsenic acid? A. I can't answer that definitely, I am afraid. We had instructions to do that. Whether it was printed on the order or whether it was phoned in to us, I can't say.

Mr. Owen:

You don't mean, Mr. Lyon, to infer the arsenic acid was shipped separately from the hydrochloric?

Mr. Lyon:

I am trying to find out—

Mr. Owen:

(Interrupting.) The form of your question indicated the arsenic acid was shipped separately.

Mr. Lyon:

Oh, no, no. I didn't mean to infer that. This shipping record has some lines below the last entry for the month, just a notation "2 gal. arsenic Pure."

Q. It doesn't say what about it any more than that?

A. That is the only Pure Oil shipment of the month.

I think I probably put that notation in at the end of the month. I can't say whether the order I received from the Sales Department for this shipment #38118 showed that we were to include with that acid that arsenic. I do know some of the orders received did specify. In later shipments the orders did specify we were to add the arsenic, I remember that. The photostat you show me of order 38118 looks like one of our orders. It has the correct order number.

Mr. Lyon:

I will ask counsel if there is any question about this photostat being a correct photostat of the order in question (handing same to Mr. Owen).

Mr. Owen:

There is no question but what that is a photostat of the order.

The Court:

It's good enough for me if they want to put it in the record.

Q. You don't find on that order any reference to any

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shipment of arsenic material, do you? A. It doesn't appear on this order.

This shipment record for March begins and sets forth, commencing at the top, consecutively down, that we made six shipments of hydrochloric acid from our plant in March, 1932. And then below that there is a total of the March sales and some percentage figures of some kind. And then down below, several lines further down, entirely detached, is what appears to be a notation "2 gal. arsenic Pure Oil." I believe that is in my handwriting. That probably was written in there at the end of the month.

Q. Why wasn't it included in the entry for the shipment at the time the shipment was made? A. The purpose of this is to provide accounting for all materials used or sold. At that time we didn't make individual entry of that two gallons, evidently. There may have been other shipments in the balance of the month. Our purpose was to put down the total in order to account for the material.

The photostat you show me of order No. 3537 of The Dow Chemical Company, Pure Oil Company is the order 40327, the order number for this March shipment to the Pure Oil Company. It does not show any reference or contain any item calling for the shipment or the inclusion of the arsenic.

Mr. Lyon:

I understand counsel to say that there are no bills showing the inclusion of the arsenic material for the February shipment, and I would like to have—

The Court:

He didn't say that he was sure about that.

Mr. Owen:

No, I am not sure about that. We are willing to produce whatever we have.

Mr. Lyon:

Well, I would like to have the bill for this March shipment, if you can get it.

Mr. Owen:

We will produce the bills for the first—how many would you like, Mr. Lyon?

Mr. Lyon:

Just for those two (indicating).

The Court:

When do you claim that you began to charge for this?

Mr. Owen:

I think the first charge was on March 11, 1932, at least that is my understanding.

The Court:

And you think they kept it up after that?

Mr. Owen:

Yes.

The Court:

Well, you can bring in the first two, and then be prepared to tell us if you did charge for it every time thereafter.

Mr. Owen:

To the Pure Oil Company. I think possibly that free treatments were given to some other oil companies, just to get them interested.

The Court:

I see.

The Court:

Do you charge so much a gallon, or do you do like they do in automobile concerns, make a charge for time and material both?

Mr. Owen:

I think they charge a lump sum for the material and the—

The Court:

Then you are not going to get what you expect. This is an inter-departmental charge that you have got here.

Mr. Owen:

Yes.

The Court:

If it turns out the way he thinks, it is going to be different from what you think. I understand that they just made a lump charge of so much for a well, is that right?

A. I cannot answer for the accounting end of it.

The Court:

Did you say that it was labor and material?

Mr. Owen:

I think that will all be cleared up by a later witness, who will undoubtedly have access to these records. We were selling service. We did not charge merely for the acid. We made a lump charge for the acid, including the service of putting it into the well.

Mr. Lyon:

We have the order number. We have certain photo-stats of later orders, Your Honor.

The Court:

But, what I understand, those are inter-departmental orders.

Mr. Lyon:

They show a charge, they show an order from the company and they show one part of arsenic acid, \$3.19 to be charged, I suppose, to the company.

The Court:

I don't know. That is what they are going to let us know.

Mr. Lyon:

That is what the customer is ordering on the order sheet.

The Court:

Is this an order from the customer or an order from one department to another? A. Those are the orders we receive from the sales department to make the shipment. That is not an inter-departmental order.

Mr. Owen:

This is not a billing to the customer, is it? A. No.

Mr. Owen:

It is an order. A. It is our order to make the shipment.

Mr. Owen:

It is an order to your department to make the shipment. A. That is right.

The Court:

I thought it was a department order. One department to another.

Mr. Owen:

That is what it is, Your Honor.

A. It is from the sales department to the plant to ship.

Mr. Lyon:

Do you know whether they bill the customers for any of this arsenic acid on the bill? A. The billing is an entirely different department. I can't answer that.

The Court:

Different price, probably, too, but we will have to find out about it. You are just guessing, you and I.

Mr. Lyon:

So that I can explain the point, we will offer proof to show under this patent to the Pure Oil Company, the Pure Oil Company went to the Dow Company with their invention in December, I think, 1931, and it is our understanding that actual shipment of ordinary acid, commercial acid, without any inhibitor, was made to the Pure Oil Company and used by the Pure Oil Company in acidizing wells; couple that evidence with evidence when this application was filed, and prepared,—the information was, it was written down, that this use of this inhibitor was optional and not necessary in the process, and now that they are finding there is nothing to talk about it in the language of the patent except the inhibitor, they are making the inhibitor their all-important thing, whereas it started out with the Pure Oil Company idea of reviving the old Frasch process.

The Court:

This is mighty important, what we are talking about here now, and the very fact that is written on afterwards. I don't mean there was a juggling of the books for the Patent Office, but it may be it was put in their order, and you filled out the order for that, and somebody went back and thought they used two gallons in everyone of those. I don't know what. But, if it seems to be inserted in there, we better get to the bottom of that.

Donald D. Hall

Mr. Owen:

We will try to clear that up, Your Honor. Now, the next thing I have is Mr. Hall's shipping record. Mr. Hall was a witness, Your Honor will recall, and he produced a typewritten list of acid shipment records which is in evidence as PX-12. On cross examination counsel called attention to the fact that the shipment record of hydrochloric acid for February, 1932, has an entry "2 gal arsenic Pure Oil" written at the bottom below the other entries, and Mr. Hall testified that he couldn't recall when he made that entry, which he thought he made at the end of the month.

Now, in order that the record may be complete I am going to offer a photostat copy of the sheet containing the shipment record of hydrochloric acid for each month during the first half of the year 1932.

And I call attention to the fact that in the January sheet there is no entry showing a shipment of hydrochloric acid to the Pure Oil Company, and there is no entry showing a shipment of any arsenic acid during that month; that in the record for February there is one item, which is No. 2 on the sheet and reads:

"2-11, order No. 38118, Pure Oil Co. Mt. Pleasant oil field, one wagon, 15 per cent HCl," and then under the column "Net weight," "790," and down below the other entry, there are seven entries in a row, and then below that is written this entry:

"2 gal. arsenic, Pure Oil."

In the March sheet item No. 2 is dated 3-11, the order is 40327, Pure Oil Co., oil field, it looks like 5000 pounds of 15 per cent, and underneath "Net Weight," "750."

Then down below the other entry is an entry similar to the one on the February sheet, reading:

"2 gal. arsenic, Pure Oil."

On the sheet for April there are two entries indicating shipments to the Pure Oil Co., No. 2 being dated 4-5, the order number 42,252, Pure Oil Co., Oil field, one tank W., looks like 68 cubic feet, 15 per cent HCl. It is not very

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clear. The net weight is 750, and item 4 is dated 4-7, or 2-7, I can't tell. I think it is April 7th. The order is 44094, and the consignee is Pure Oil Company, Mount Pleasant, Michigan, one tank W. 68 cubic feet, 15 per cent, and the weight is 750.

And at the bottom of that, or below the entries on that sheet appears this entry:

“4 gal. arsenic acid, Pure Oil.”

The next is the shipping record for May, 1932, and it contains six shipments to the Pure Oil Company, Mount Pleasant, Michigan, being Nos. 2, 6, 7, 8, 9 and 10 on the list, and the amount of the shipment is 750 net pounds in each one, net weight, and below on the page is this entry:

“12 gal. arsenic, Pure Oil.”

Then there are two sheets for June, and they contain, as I count them, 13 shipments to Pure Oil Company, and then shipments to other companies, the Columbia Oil & Gas Company, and different ones; and at the bottom appears this entry:

“44 gal. arsenic, Pure Oil; 28 gal. arsenic, Misc.”

Now, some of those Pure Oil shipments were of 1500 net pounds, instead of 750 net pounds. For instance, entry No. 21 was for 1500 pounds, and entry No. 23, entries 24, 25, and 26, each for 1500 net pounds, and No. 28 also, and No. 31, and No. 33—those were all shipments to the Pure Oil Company.

Mr. Owen:

So I will ask that copies of those sheets for January, February, March, April, May and June of 1932 be photostated and offered in evidence as one exhibit, and marked PX-246.

The Court:

That will be done.

(The photostatic copies will be marked Plaintiff's Exhibit No. 246.)

The Court:

The purpose of the reading was so that the record might show the portions of this that you relied upon?

Mr. Owen:

Yes. The purpose of it was this, that those shipments to the Pure Oil Company of hydrochloric acid, and the entries of shipments of arsenic acid to the Pure Oil Company, register in every instance 2 gallons of arsenic acid to 500 gallons of hydrochloric acid.

The Court:

The first one was no charge?

Mr. Owen:

The first one was no charge, but the entry of arsenic acid is the same.

The Court:

The same for that one?

Mr. Owen:

Yes. And then it is there for the second, third, fourth, and so on.

Mr. Lyon:

It is not in accordance with the keeping of regular books. It is down at the bottom.

Lawrence W. Lee

LAWRENCE W. LEE,

a witness called by plaintiff, testified as follows:

DIRECT EXAMINATION

I am an employe of Dowell, Incorporated, and I live at Midland, Michigan. I have been an employee of Dowell, Incorporated, since 1932. Previously I was employed by the Dow Chemical Company since 1928. I was in the Service Department of the Dow Company and had charge of trucks, yards, and the general clean-up of the plant. I recall the time when the first oil well was acidized by the Dow Chemical Company for the Pure Oil Company. Our particular department transported the acid from the plant to the well location, it was my duty to secure a receptacle from the Acid Division in which to transport the material. The container for the acid was a wooden tank normally used by the Acid Division for transporting acid between plants. That was the first time one of those tanks had been used for such purpose, as far as I know. That was in 1932. I know that from tying it into other treatments which came later and in which I was personally interested. That first shipment made to the Pure Oil Company was before May of 1932. It was approximately sixty to ninety days before May.

By Mr. Owen:

Q. What is there about May that fixes this in your mind? A. In May of 1932, I made arrangements with the Dow Chemical Company to secure some inhibited acid, and the services of one of their men, for treating some wells in which I was interested.

I actually saw the inhibitor go in the first well that was treated for me, and I had knowledge of their previous use of inhibitor in the acid they were using in the wells of the Pure Oil Company. I knew about that by discussions with Ross Sanford, whom we worked with very closely, and with Dr. Grebe of the physical laboratory.

Lawrence W. Lee

Q. And when, with reference to that first shipment of hydrochloric acid to the Pure Oil Company well, did you have occasion to have conversation, the first conversation with Dr. Grebe and Mr. Sanford, or either of them, on the subject of an inhibitor in that acid? A. The first conversation with Dr. Grebe was previous to the Pure Oil treatment, and it occurred after our department had trucked acid in carboys to a Dow well directly in front of the office from which we operated. And the purpose, my purpose in talking with Dr. Grebe was to find out what protection we should give our men in handling the acid which was going into this well. And at that time we discussed the handling of the acid and the manner in which it was going to be put into that well. That was previous to the first Pure Oil Company treatment. In my opinion it was a few months before. I do not recall whether or not during that conversation anything was said on the subject of inhibiting the action of the acid on the well equipment. I first learned that an inhibitor had been used or was to be used in this first Pure Oil treatment about the time I was making arrangements for securing the tank to take the acid to the field for that particular treatment.

Q. Then before that treatment was made you had information or had been informed that they were going to use an inhibitor in the acid; is that correct? A. Yes, sir.

Mr. Lyon:

I object to that as leading and suggestive.

The Court:

"About the time," I would rather you wouldn't—let's let him fix it as near as he can with reference to when he actually took it out. That is all that we can get now. A. It was at the time that the first treatment went to the field of Pure Oil that we discussed the use of the inhibitor.

The Court:

At the very time, you mean? A. Yes, sir.

The Court:

The very day? A. Within one or two days. It was at the time we took it up.

By Mr. Owen:

Q. How are you able to state that you talked about inhibitors at or within one or two days of the time of that first Pure Oil treatment? A. Well, in discussion of how it was to be handled Mr. Grebe stipulated that Mr. Quinlan, who worked for Grebe in the lab, was to put in the inhibitor and would handle the mixing of it, as there was danger in handling the material that they used.

I learned at that time that the inhibitor they proposed to use was arsenic acid. It was to be obtained from the lead arsenate plant. It was a product or by-product of that plant.

Q. Now, after that first treatment, when did you next discuss this question of an inhibitor being used in the acid, if at all, and with whom? A. The next time that I can remember discussing the use of the inhibited acid—

The Court (interposing):

Is that the first acid that went to the field? A. That is the first acid that went to the field; yes, sir, to the Pure Oil well.

The Court:

Now, is there any relation between that—you have already told us about using a wooden tank? A. Yes, sir.

The Court:

Did the talk have anything to do with the wooden tank? A. We had to secure a tank or some receptacle for taking it to the field.

The Court:

Yes, but what about this emphasis of the wooden? Was that emphasized in any way when you talked about it? A. No. That is the only receptacle we had at the time for taking it to the field.

The Court:

That is the only one you had? A. Yes. I made contact with Mr. Curtiss of the Sales Department for the purchase of sufficient acid to treat five wells, five hundred gallons to each well, and it was stipulated that Mr. Quinlan would have the inhibitor and assist or supervise the treating of the wells, and that was done.

Lawrence W. Lee

Q. I call your attention to Exhibit 12 in this case, which is a list of shipments of inhibited acid produced by Mr. Hall, and on this list I find under date of 6/4/32 an entry of a shipment to Lawrence Lee of 500 gallons of 15 per cent acid, and a note on the margin of the use of arsenic in connection with it.

This was one of the treatments that I have just referred to. On that treatment I saw the inhibitor go into the tank. The entry under the date of 6-9-32 also was one of our wells. I do not know by definite observation whether or not an inhibitor was used in that acid. There was an understanding on that subject. All of the acid to be bought was to be inhibited acid.

Mr. Lyon:

We are not contesting that. It is in agreement. You can put that summary in. We agree, commencing in June that these wells were treated with inhibited acid, with acid containing inhibitor.

Mr. Owen:

Well, then, I won't pursue that line any further.

The Court:

Well, now, the first well this witness has testified about was in 1932?

Mr. Owen:

The first well he was personally interested in; the first well he has testified about was the Pure Oil Well treatment of February 11, 1932.

The Court:

All right. What has he said about the inhibitor in that?

Mr. Owen:

Will you repeat what you said about the inhibitor in that first treatment for the Pure Oil Company? A. I stated that I personally made arrangements for obtaining the receptacle in which the acid would be transported to the field and I stated that I discussed the use of inhibited acid with Mr. Quinlan and Mr. Grebe previous to that at the time.

The Court:

You had to do with the transporting, as I understand?

A. Yes.

The Court:

Why were you concerned whether it was inhibited or not? I find no connection for the reason you happened to do that. A. I am responsible for the men in that division and our men were handling the material. They were loading the acid and would be transporting it to the field. The information regarding inhibitor was advanced by Mr. Grebe's department inasmuch as he considered there was a certain amount of risk in putting in the acid or handling it physically, and he wanted his own men to put the inhibitor in instead of the men from the Service Department.

Mr. Owen:

I think what the court wants to know is how you happen to know so much about furnishing the truck for that first equipment. A. Dr. Grebe discussed the handling of the acid. I am talking about the arsenic acid, which is the inhibitor which goes into the tank.

The Court:

Is that dangerous to a man? A. Dangerous if it gets on your hands, finger nails.

The Court:

More than the hydrochloric? A. Yes, sir.

The Court:

I know acids and I don't see why a chemist would discuss with the trucking department what kind of acid.

Witness:

I worked for the Dow Company up to about the time Dowell was incorporated and then went over to them. My first duties for Dowell Incorporated were building of equipment, starting stations in the field and the operations in the field. I installed stations during the early period at Louisiana, three stations in Texas.

The first station was opened at Midland, Michigan, operating from The Dow Chemical Company; the next station at Muskegon, opened in September, 1932. Our depart-

Lawrence W. Lee

ment moved the equipment over there, and two of our men from that department were transferred to that station about that time. The next station was opened in North Baltimore, Ohio. I was working with Dowell at that time, at the time that was started. Horse Cave, Kentucky, was the next station. Manning, Louisiana, was the next station. That was started in December of 1932, although no equipment arrived until January of 1933. Texon, Texas, in January of 1933. Russell, Kansas, approximately the same time, in January of 1933. Then Breckenridge, Texas, in February of 1933.

I am now in charge of the purchase of materials, auxiliary treating materials, and have been in that branch of the business since March of 1933. Since that date I have had knowledge, through my purchasing of materials, of what was being used. My records show what this inhibited acid was called. It was called Dowell X. They started calling it Dowell X in 1933. At one time before that it was known as Dow limestone solvent. It has been called Dowell X since that name was adopted. That indicates in our accounting, inhibited hydrochloric acid of 15 per cent strength.

The advertisement, photostat copy of which you show me, appeared in the Oil and Gas Journal for December 1st, 1932. This advertisement is familiar to me. I saw it at the time it came out.

Mr. Owen:

I will offer that as Exhibit 15.

(The photostat of advertisement referred to was thereupon marked PX-15, July 24, 1941.)

CROSS EXAMINATION

Referring to this first order for the job of the Pure Oil Company, dated February 11, 1932, I saw the load leave the yard, I saw the load leave the service station.

By Mr. Lyon:

Q. Are you sure that that was not called for by the Pure Oil Company with its own truck? I will show you the order to see if that will help you refresh your recollection.

tion (indicating). It specifies on the order, to be called for by the Pure Oil Company truck (handing the document to the witness). A. (After examining the document): I would think that it would be called for by the Pure Oil Company if this order says so. I have no actual recollection as to whether it was or not. It was shipped in a wooden tank, I am sure of that. I made the arrangements for securing the tank.

Q. Did you actually see the shipment, see the wooden tank put on the truck? A. I saw the—no, I would not say that I did.

The Court:

Just let me understand you. If they called for it with their truck, would that still mean that it was in your tank?

A. Yes.

The Court:

You know that it would not be in their tank? A. Yes.

The Court:

Obviously, a truck used in that business, might go over and get stuff dumped into it and go away with it, but that is not right in this case? A. That tank when it came in would have to come in the gate, and when they came in with the tank—

The Court:

You mean tank or truck? A. When the truck came in, it would come in the gate, and it would come over to the department where the tanks were. Then it would have to be taken from the wooden trucks on which it was carried around the plant, and put up on their truck, if their truck was used, and tied down when loaded. A wooden tank would be put on another flat bottom truck.

The Court:

They don't have trucks like we use for the threshing machine? A. They do now, sir. They didn't at that time.

Q. Didn't the Pure Oil Company have such tank?

A. Not at that time. They later built a tank.

Q. Now, why was it necessary to ship the acid in a wooden tank? A. I don't know as it was necessary. That

was the only receptacle we had in the plant which was available for that use.

Q. You did not have any other tank in the plant at all except a wooden tank? A. That was the only thing we were using for acid at that time.

Q. I understand that. Why did you use a wooden tank for acid? A. Hauling acid you would naturally think of the acid receptacle that you had around the plant.

Q. I mean why did you have wooden tanks around the plant to carry acid? A. The acid hauled around the plant is raw acid.

Q. And, you had never thought here in the Dow Company of adding an inhibitor to your acid so that it wouldn't corrode metal tanks if you used metal tanks? A. Well, I am not an authority. If you want my opinion I would be glad to give it to you.

Q. I am trying to find out why did the Dow Company go to the trouble of handling the acid in wooden tanks. Was it because— A. (interrupting) They want the acid in the pure form. They are using it in a process.

Q. What process? A. Processes around the plant. They are hauling from one plant to the other in their work, and manufacturing processes. It is taken from one plant to another for use in reacting other processes.

Q. Do you know whether the inhibitor would interfere with any of these processes that the acid was to be used for? Do you know that of your own knowledge? A. No.

Q. Well, how long was it after this shipment to the Pure Oil on February 11 before your company got a steel tank to handle acid? A. The first record I have is in August or September of that year. They may have been built earlier. I don't know. Then after that we shipped our acid from the stations out to the wells, to the point of use, in steel tanks and the acid contained the inhibitor. The inhibitor was added at the station. We have continued that practice up to the present time since at least Septem-

ber, 1932, that has been the regular practice in our company.

We started using arsenic acid as the inhibitor and continued it until the fall of 1932. We then used an inhibitor which we call Retarder, made in our own plant. I am not familiar with the contents of it, but understand that it was a mercaptan base material. Mercaptan is a sulphur compound. I don't know where it came from. You can smell it in some of these Michigan oils. We have used it at intervals. We are still using that same inhibitor in refined form. It is the principal inhibitor we have been using practically all the life of Dowell. That is, we have used it all through Dowell. And at the present time it is the only inhibitor we are using, with the exception of one other inhibitor, which is a material purchased from the Barrett Company. They sell it for pickling. They sell it to the trade as a pickling compound. It has been about a year since our company has used any arsenic acid or other arsenic compounds or agent.

All the acid that we transport out to the field from our stations contains an inhibitor, and in many cases this added surface tension reducing agent, and it is that acid which you pump down or introduce into the well through the well tubing. For some time we bought an inhibitor from the American Paint Company, from 1934 to 1936, or 1937. I believe that we bought our first in late '34 or early '35, and we bought our last in '36, I believe. That was an inhibitor or a pickling compound called Murodine. We used that for several years in conjunction with our own material as a retarder. In some cases we have used it alone. When we used it in conjunction with our own material, we mixed it with our mercaptan. We bought the Murodine from Mr. Gravell's company, the American Chemical Paint Company.

RE-DIRECT EXAMINATION

We now use wooden tanks for transporting hydrochloric acid from one of our plants to another. As to whether we ever used any other kind of tanks for that purpose, we have used some rubber lined tanks and may be using them now. I am not positive of that. But we never used any unlined steel tanks to my knowledge.

The reason why steel tanks, unlined steel tanks, are not used for shipping or transporting acid from one plant to another in our plant at Midland is because the raw acid would attack the steel tank. There is no reason for inhibiting it in the tank from one place to another, and lots of the processes in the plant, in my opinion, there is a possibility that it would throw off the reaction. We wouldn't want to use it. In other words, pure hydrochloric acid or commercial hydrochloric acid is desired for reaction in our plant.

RE-CROSS EXAMINATION

In our company ever since September, 1932, we have used unlined steel transportation tanks for conveying the acid from our stations out to the wells in which it is to be used. Since we first started, that would be August or September, or in that summer, 1932, to my knowledge we have only transported acid to our customers in unlined steel tanks.

RE-DIRECT EXAMINATION

When The Dow Chemical Company first began to acidize oil wells for the purpose of increasing production there was no one else in that business, to my knowledge. There was some competition started in Michigan in the summer of 1932. That was a firm known as the Oil Makers. It constituted Edgar S. Lee and a man by the name of

Dougherty. They continued in business about a year, I think.

The Court:

Where were they located? A. Edgar is my brother. Located in Midland, Michigan. Dougherty is the driller on the wells which were treated by our company or myself, the driller that drilled the wells.

Q. And were they working under any arrangement with the Dow Company? A. I think that they purchased inhibited acid for one or two treatments but outside of that, they got their material from other sources. I do not know why they stopped.

Mr. Lyon:

If Your Honor please, I think this evidence about other people is immaterial and irrelevant. It is subsequent to the application for the patent. How would we meet it or what collateral issues would it bring in in this case if we wanted to question why it stopped? It isn't worth trying, I don't believe, all those matters.

The Court:

It is material in that it shows the growth of the business; that theory that revolutionized the business along that line. As they started up, others tried the same thing.

Mr. Owen:

That is the purpose of it.

The Court:

It hasn't very great weight, I will assure you of that, but I will let you show it.

Witness continuing:

A man by the name of Ricou, Shreveport, Louisiana, and a company later known as Chemical Process started along about that time, thereabouts. It would be the fall of '32 or early '33.

The Court:

Where were they located? A. In Breckenridge, Texas. Williams Brothers Company came into the picture in 1933, I believe. They were the ones that were sued.

RE-CROSS EXAMINATION

I have heard of The Chemical Process Company. They started in business in the fall of '32, as near as I know. They are still doing some business. Their main office is at Breckenridge, Texas. They operate in Texas, operate some in Oklahoma, I believe they are operating some in Louisiana, and some in Kansas. They have no rights to operate under the Dow patents, to my knowledge.

Q. And you don't claim that they use inhibited acid?

A. I don't claim anything about the process.

Q. Don't you know what they use? A. No, sir. Their business is acidizing oil wells and they are a direct competitor of the Dow people and have been before the Halliburton Oil Well Cementing Company went into this business. They are still in business and we are not now suing them, to my knowledge. I wouldn't know whether we sued them in 1934.

Mr. Lyon:

If Your Honor please, I will offer in evidence at this time a certified copy of the papers on file in the United States District Court for the Eastern District of Oklahoma in the suit entitled The Dow Chemical Company, plaintiff, vs. The Chemical Process Company, defendant, in Equity No. 4523. This consists of a bill of complaint for infringement of the Grebe-Sanford patent, an answer filed by the defendant, a set of interrogatories propounded to the defendant, the defendant's answers to the interrogatories, and a stipulation that the cause be dismissed, and an order dismissing the cause.

Mr. Owen:

Dismissal without prejudice.

Mr. Lyon:

I will ask that this be marked Exhibit 16. (Exhibit 16 marked.)

Fred H. Brown

FRED H. BROWN,

a witness called by plaintiff, testified as follows:

DIRECT EXAMINATION

I am assistant treasurer of the Dow Chemical Company. Previously I was assistant secretary for about four or five years. As assistant treasurer I have access to the accounts of the company, and here produce the records of shipments of 15 per cent hydrochloric acid by Dow Chemical Company to the Pure Oil Company, beginning in February, and running on through for several months during 1932.

By Mr. Owen:

Q. Will you explain what these are that you have produced? A. The first bundle is our original invoicing instructions consisting of ten sheets. The first sheet is dated February 11, 1932, and it is made out to our Chlorbenzol department. This form is filled out by our sales department and goes in duplicate to our traffic department. This buff copy is retained, and the yellow copy goes out into the plant. The ones I have produced are retained in our traffic department, and a yellow copy goes out into the plant or the department to fill the order. All of the typed information with the exception of the price is on that yellow copy. That first one happens to be a no charge order.

Q. And the next one, which is Order No. 40327, has typewritten matter and also the entries in pencil. Will you explain what those entries are? A. Well, all the typed material, all the typing is on the form which goes into the department, with the exception of the price.

The Court:

The sales department makes out the typing? A. Yes, they make all the typing. The sales department fills in the price in the copy which it keeps, but the price doesn't go on the copy to the other departments.

Fred H. Brown

Referring to the typewritten matter on this first order No. 28118, the department is "Chlorobenzol" dated "February 9, 1932," and the "Invoice To" block is written "Same," because it says "Ship to Pure Oil Company" and if they are the same we usually write "Same" up there, and the X "Ship to" is "Pure Oil Company, Mount Pleasant Oil Field," and "To be called for by Pure Oil Company Truck February 11th." Down below there is originally written "70 carboys hydrochloric acid," and in parentheses "Strong," and "No charge" in the price column. "70 carboys" was later changed to "one wagon load."

Then on the second one of these orders, which is Order No. 40327, under department is "Hydrochloric Acid" and in parentheses "Don Hall" in charge of that department. Dated March 9th, 1932. Invoice to "Same" "35 East Wacker Drive, Chicago, Illinois." The date to be shipped is "Will call for March 10, 1932." It was shipped to Pure Oil Company oil fields, and the route is "Pure Oil will call for," and the special instruction to traffic and shipping clerk "Pure Oil will call for March 10, 1932." The shipment was to consist of 500 gallons approximately 10 degree Baume hydrochloric acid to be loaded in tank wagon, and there is a "plus handling charges" and "erlc" or whatever.

The Court:

Would that be about fifteen per cent, when it is all loaded?

Mr. Owen:

It is just about fifteen per cent.

Q. Now, the order No. 42252, which is the next one, I see is to the same department and to the same company, the Pure Oil Company, the same shipping instruction. Will you read what the shipment was to be? A. Five hundred gallons approximately 10 degree Baume hydrochloric acid, plus two portions arsenic acid. Total \$6.38, and labor tank service transferring charge, that is \$5.80.

For order 40327 there was a total charge of \$22.18. It

Fred H. Brown

was 500 gallons approximately 10 degree Baume hydrochloric acid, figured out at 4500 pounds, at \$14 per ton, on the basis of 18 degree acid, came to \$17.50. And then there is a handling charge, \$4.68, making a total of \$22.18. The next invoice or the next order, 42252, calls for 500 gallons approximately 10 degree Baume hydrochloric acid figured out to 2500 pounds at \$14 per ton on the basis of 18 degree acid. That is a total of \$17.50. Plus two portions arsenic acid, \$6.38. And labor tank service transferring charge, \$5.80. Total \$29.68.

The invoicing date of order 38,118 was February 11, 1932. Order 40327 invoicing date was March 11, 1932, and order 42252 invoicing date was April 5, 1932.

The Court:

Does that make three or four shipments of acid?

Mr. Owen:

Three.

The Court:

And the first one no charge?

Mr. Owen:

No charge. I am going to show later from the ledger sheet the payments made.

The date of the next one, Order 44,094, was May 3, 1932, for 1 Tank Load 500 gallons Dow Hydrochloric Acid, Approximately 10 Baume, \$17.50. One portion Arsenic Acid, \$3.19, Labor Tank Service Transfer Charge \$4.00, a total charge of \$24.69. That shipment went to the Pure Oil Company? A. Yes, sir.

Q. Now, will you go through each of these other six order numbers and state—they were all shipped to the Pure Oil Company? A. Yes, sir.

Q. State in connection with each order—the order number and the material shipped and the price charged for the material. A. Order 44793, invoice date May 5, 1932, called for 1 tank load 500 gallons Dow Hydrochloric Acid, approximately 10 degrees Baume, \$17.50; 1 portion arsenic acid, \$3.19; labor tank service transfer charge, \$4.00. Total \$24.69.

Fred H. Brown

Order 46068, dated May 21, 1932, 1 tank load 500 gallons Dow Hydrochloric Acid approximately 10 baume, \$17.50; one portion arsenic acid, \$3.19; labor, tank service, transfer charge, \$4.00, total \$24.69.

Order 46377, invoice date May 25, 1932, 1 tank load 500 gallons of Dow Hydrochloric Acid approximately 10 baume, \$17.50; 1 portion arsenic acid, \$3.19; labor, tank service, transfer charge, \$4.00; total \$24.69.

Order 46567, invoice dated May 27, 1932, 1 tank load of Dow Hydrochloric Acid, 500 gallons, approximately 10 baume, \$17.50; 1 portion arsenic acid, \$3.19; labor, tank service, transfer charge, \$4.00, total \$24.69.

Order 46568, invoice May 28, 1932, 1 tank load, 500 gallons, Dow Hydrochloric Acid, approximately 10 baume \$17.50, 1 portion arsenic acid \$3.19, labor tank service transfer charges \$4.00, total \$24.69.

Order 46763, invoice date May 31, 1932, 1 tank load, 500 gallons, Dow Hydrochloric Acid, \$17.50, one portion arsenic acid \$3.19, labor tank service transfer charge \$4.00, total \$24.69.

The last seven orders were for the same amount of hydrochloric acid and each included one portion of arsenic acid and a charge for tank service, and the total charge in each one of them was the same amount, \$24.69.

Referring to the second of these orders, which is dated March 11, 1932, I find no charge for arsenic, but in the third one I find charges for two portions of arsenic. The charge for these two portions of arsenic is twice the charge for one portion of arsenic included in each of the subsequent orders. The amount of hydrochloric acid in each of those ten invoices or orders was the same, 500 gallons.

Q. Now, I will ask you if you can account in any way for the fact that the second order included no charge for arsenic acid, and the third order included charges for two portions of arsenic acid, and each of the subsequent orders included charges for one portion of arsenic acid?

Mr. Lyon:

I object to that on the ground this witness can't testify

Fred H. Brown

to anything except that he identifies these records. He doesn't know any more than the records, and the records speak for themselves.

The Court:

Witness, as you have only been assistant treasurer for a short time, I will ask you if as assistant secretary you did have access to these sheets and books? A. Yes, sir.

The Court:

During all the time you have been working there? A. Yes, sir.

The Court:

I will overrule the objection. Those familiar with accounts can read between the lines, where someone else can't, and I will let him interpret. A banker can tell you where a check went by his own system, while a stranger couldn't, at least with any ease, interpret it. All right witness. A. It is apparent that the charge for arsenic acid was omitted from the first shipping instruction and they were charged two portions on the following shipping instruction.

Q. And I will ask you whether or not the charge for the two portions in the third shipment and for no portion in the second shipment would be consistent with the fact that one portion was included with each of the second and third shipments?

Mr. Lyon:

I object to that as argument, and leading the witness.

The Court:

Pretty much that way. I will overrule the objection though and take the answer. A. I believe it was.

The Court:

I take it that his is more a line of reasoning and conclusion than what I thought was an interpretation of it. Isn't your line of reasoning quite largely based on the fact that at no time have you found so much of the inhibiting arsenic supplied and charged in any item as would be in the third, but that would be an unreasonable amount for them to use and put in from your custom and experience and the way it is done? A. That is right.

Fred H. Brown

The Court:

And that seems to me with the other is the reason why there was no charge for it before.

Mr. Lyon:

Your Honor in your statement referred to the witness' experience in the way it is done. He hasn't any experience. He keeps the record.

The Court:

I agree my argument wasn't very good, but I can't get the answer. I didn't base it on what he would and I am glad he didn't follow my suggestion and didn't let me lead him, and it is very largely logic, but it seems to me it is a fair conclusion. I will let it stand and you can argue something else about it to me.

Mr. Owen:

I will ask that this bunch of ten orders to which the witness has referred be marked Plaintiff's Exhibit No. 231-A, B, C, D, E, and so forth.

(The documents above referred to were thereupon marked Plaintiff's Exhibits 231-A to 231-J, inclusive.)

The Court:

In other words, here the total, if I counted right, are nine charges, or was it some other number, or nine batches?

Mr. Owen:

Nine batches.

The Court:

Nine batches that went out. The first one they didn't charge for.

Mr. Owen:

There were ten batches with the first one.

The Court:

I didn't keep account of that. There were ten batches all told and all the books and everything show the first one they didn't charge for.

Mr. Owen:

That is right.

The Court:

Well, your nine uniform batches of inhibitor charged

Fred H. Brown

for, if we spread even over there, but as it is there is the second one, no charge, and the third one would be what it is in all the others?

Mr. Owen:

That is right.

The Court:

And I would just naturally reach the conclusion that there was inhibitor in every one of the ten. The first one they didn't charge for and that they charged them for nine inhibitors, but they got two of them on one and none on another. All right.

I have here the accounts receivable record of the Pure Oil Company account. On Order 40327 is given Folio No. 3537, and that is posted on our accounts receivable, 3537 folio, dated March 14, a charge of \$22.18, which corresponds with the charge on the order, without the arsenic. Order No. 42252 is given Folio No. 4516, was posted on April 5, for \$29.68. That corresponds to the total of \$29.68, and included the two portions of arsenic.

The Court:

It says "two portions."

Mr. Owen:

Yes.

Mr. Lyon:

This is a shipping order. It says ship two portions April 5.

Order 44094 is given Folio 5977, was posted on May 3rd, at \$24.69. That agrees with the total on that order.

Order 44793 was given Folio 6121, posted on May the 5th, \$24.69, and that agrees with the total of that order.

Order 46068 was given Folio 7105 and that was posted May 21st, for \$24.69, and that agrees with the total of that order.

Order 46377 was given Folio 7323. That was posted May 25 for \$24.69, and agrees with the total on that order. And that is true with all the rest of them.

Q. Does this ledger account show whether or not those items were paid for by the Pure Oil Company? A. Yes,

Fred H. Brown

sir. When the checks come in, we make a check mark after the amount of the invoice, and those are all checked off. From time to time, the account is balanced.

Mr. Owen:

I will not offer these ledger sheets unless counsel wants them or the court wants to see them.

The Court:

I don't care to see them. I am satisfied.

CROSS EXAMINATION

The ledger sheet shows that the shipment of March 14th, which is the second shipment here referred to in the amount of \$22.18, was paid March 31, before the date of the third shipment. It was actually paid by the Pure Oil Company before the date of the third shipment, and the amount paid for was just the amount of \$22.18.

Q. And that is the amount your books showed was being charged for hydrochloric acid without any inhibitor in it without any arsenic in it, isn't that correct? A. I don't know whether there was any in it.

Q. I mean these records that you have produced here, these shipping records, you are selling hydrochloric acid at the rate of \$14.00? A. Yes, sir.

Q. And the additional price was charged for arsenic above that rate? A. Yes, sir.

Q. And this record of this shipment of March 14, 1932 shows that the shipment was charged for at the rate of \$14.00 and was paid for at that rate with no charge or no payment for arsenic? A. No, sir.

The Court:

And on all of those shipments one portion of the arsenic was charged at the uniform price each time? A. Yes, sir.

The Court:

And each time it was 500 gallons of the acid? A. Yes, sir.

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The Court:

And the charge for that was uniform, too, as I recall it? A. Yes, sir.

The Court:

And the first one was never paid for because no charge was made; the second one was paid before the third one was delivered or charged for? A. Yes, sir.

The Court:

And they have all been paid for? A. Yes, sir.

The Court:

Well, we have all we can get from this witness.

Mr. Lyon.

I don't think this witness can help us any more. He would be guessing. We might as well guess as to ask him to guess.

SHERMAN W. PUTNAM,

a witness called by plaintiff, testified as follows:

DIRECT EXAMINATION

I reside at Midland, Michigan, and am assistant general sales manager for the Dow Chemical Company. I have worked for the Dow Chemical Company since 1919, with the exception of a short time in 1929. My duties for that company during the period around 1931 and 1932 were doing market development work on the new products. I

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had something to do with the sale or attempted sale of hydrochloric acid by the Dow Chemical Company to be used in acidizing oil wells. That came within my jurisdiction after it was started. It did after the first treatments were made. It first came under my jurisdiction, so far as sales were concerned, as I recall it, late in the summer of 1932. The interest displayed by those interested in the production of oil when news of this treatment was spread around was beyond anything that we had really hoped for in that line.

Mr. Lyon:

Well, to save time, Mr. Owen, you have been over this in depositions.

Mr. Owen:

Yes.

Mr. Lyon:

And the company received quite a large number of letters of which you have produced copies. If you want to produce them and offer them in evidence we will waive proof, without your inquiring in detail and identifying them with this witness.

Mr. Owen:

All right.

Q. Just state briefly, Mr. Putnam, the character of the inquiries that came to your attention when this sale of this fifteen per cent hydrochloric acid was placed under your jurisdiction, as a new product or a new use? A. Why, the inquiries came from all types of people, from the very largest oil companies down to all the promoters that thought they could go out and buy up all the old oil wells and make millions off from them.

Q. In what form did those inquiries come? A. Mail, telegrams, telephone, and personal visits.

Q. You testified in the Williams Brothers case, and at that time produced a number of original letters, possibly telegrams, I don't know; certainly a lot of letters, which came to you in that connection. I will hand to you what was introduced in the Williams Brothers case as Exhibit

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No. 3, and will ask you if those represent all of the letters that came to you in connection with the sale of hydrochloric acid for use in acidizing oil wells, during the period covered by those letters? A. No. These would only be just a very few representative letters of the type that came in.

The date of the first letter I have here is June 13, 1932, and the date of the last letter in that bunch is January 19, 1933. As I have stated, these are representative of a large number, a much larger number of letters that came to me during that period.

The Court:

You may go ahead. Why do you not have that whole book marked as an exhibit?

Mr. Owen:

I am going to have the whole book marked as an exhibit, but I would like to get into the record at this time the names of the concerns from whom these letters came, which constitute this exhibit.

To the witness: Will you read just the names, without going into the contents? A. Sarnia Oil & Gas Company, The Ohio Producing and Refining Company, Perkins Brothers, Inc., William E. Schwartz, Stanolind Oil & Gas Company, American Pipe & Steel Corporation, Ltd., The National Refining Company, Indian Territory Illuminating Oil Company.

The Court:

That was one of Mr. Doherty's companies, a subsidiary.

Mr. Owen:

Yes.

A. Union Oil Company of California, Empire Oil & Refining Company, Gulf Production Company, Shappell Oil Company, Hercules Powder Company, Continental Oil Company, Central Utilities Corporation, Crystal Oil Refining Corporation, Jo H. Cable, Petroleum Engineer, R. H. Brownlee Laboratory, The California Company, Union Crude Oil Corporation, Capital Drilling, Inc.,

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Laughner Oil & Gas Co., Bradford Motor Works, Anaconda Kevin Oil Company, United States Department of Commerce, Bureau of Mines.

Q. What did they have to say? A. This is written from Shreveport, and reads:

"In the August 29, 1932, issue of the Oil Weekly page 57, I notice an account of the increasing of oil production from a limestone reservoir by the use of acid. I was very much interested in this article and am wondering if you have any literature regarding the procedure and the kind of acid and amounts used in these experiments.

"Any literature or material you have would be appreciated.

"Very truly yours,

"R. E. Heithecker,

"Petroleum Engineer."

The list continues: C. E. Daugherty & Company, John A. Kay, Petroleum geologist, Cambridge Gas Company and Harvard Gas Company, Amory Petroleum Corporation, Lone Star Gas Company, Texas Pacific Coal & Oil Company, Brown Tool Company, Inc., Shell Petroleum Corporation, Simms Oil Company, Texoma Natural Gas Company, Humble Oil & Refining Company, J. & J. Petroleum Corporation, Texas Gulf Coast Production Company, United States Department of Commerce, Bureau of Mines, from San Francisco, California.

Q. What do they say? A. That is December 12, 1932:

"Gentlemen:

"I am interested in your chemical processes to increase oil production and wish you will kindly send me your booklet entitled 'How to Increase Oil Production.'

Signed "H. C. Miller,

Senior Petroleum Engineer."

William C. McBride, Incorporated, and the Silurian Oil Company, The Empire Companies, J. S. Cosden, Incorporated, B. V. Von Vitanyi.

Q. Where did that come from? A. Germany.

Q. Will you read that?

"From your advertisement in the 'Oil Weekly' I read about the development of a new chemical process for the purpose of increasing oil production.

"Being the representative of the Ingersoll-Rand Company, 11 Broadway, New York, for Germany, I am greatly interested in the new process developed by you in view of my close connections to the German oil fields around Hanover.

"Please forward your booklet describing the new method and its adaptability to different oil formations. In case you think the method applicable to European oil fields I certainly would like to join your sales organization in some form.

"Referring you to Messrs. Ingersoll-Rand Company for any information you may desire about my person, I hope to have an early answer from you.

Signed "B. V. Vitanyi."

Q. What is the date of that letter? A. That is December 15, 1932.

Q. Then go on and give the names of the other parties from whom you received letters? A. R. B. Laing, Gypsy Oil Company.

Q. Will you read the one from the Gypsy Oil Company? That is the last one, I believe. A. Yes, sir. It is dated January 19, 1933, and reads:

"We have noted with interest the result of acid treatment as applied to oil wells, and the rapid spread of this method of treatment throughout the Mid-continent area.

"We have in mind the possibility of treating certain of our wells in the State of Kansas, and in this connection would like to know whether or not your company will be prepared to service wells in that area within the near future. If you have a specific plan formulated, we would like to know the date on which your service will be available.

Signed "G. G. Sanderson,

"General Superintendent."

Mr. Owen:

These letters will be offered as one exhibit, No. 13.

(The letters above referred to were thereupon marked PX-13.)

To the best of my knowledge the article in the *Midland, Michigan, Republican* of June 9, 1932, under the heading "Treat Wells by Dow Process to Jump Production," was the first newspaper or trade journal publicity that was given this treatment. I recall having seen the article in the *Oil Weekly* of August 29, 1932—page 57—at about the time it was published.

Q. I also show you a photostatic copy of another issue of the *Oil Weekly*, page 103, but there is no date on it. I cannot tell what the date was. Do you recall about when that was published? A. Why, this came out, I believe, in late '32.

Mr. Owen:

Mr. Conner just told me it is dated November 14, 1932. I will write that date on with the understanding if it is incorrect it may be corrected.

These three photostatic copies of publications will be offered as Plaintiff's Exhibit 14, and I wish to read into the record the first paragraph of the article in the *Midland Republican* for June 9, 1932.

The Court:

I will admit them as one exhibit.

Mr. Owen:

The first paragraph of the *Midland Republican* reads as follows: "A new process of injecting acid into oil wells, which is supposed to increase the porosity of the oil bearing sand and result in a heavier flow of oil from wells which have nearly stopped producing, was announced this week by Dow officials. Oil men are showing a keen interest in the process, which they believe would revive old wells, especially since it has been said to produce as much as ten times the original flow in one stripper."

The article in the *Oil Weekly* for August 29, 1932, states:

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"Walter L. McClanahan Inc.'s Schaffer 1, Midland County, Greendale Township, SW. SW. SW. Section 12, which was drilled into the Dundee limestone about six weeks ago with an initial production of 125 barrels was boosted to 1070 barrels a day this week when treated with acid, a special solution developed by Dow Chemical Company of Midland, Michigan. The well flowed 750 barrels the second 24 hours after treatment and after five days was producing better than 500 barrels a day."

I will read also a part of the article which appeared in the Oil Weekly for November 14th, 1932, under the heading "Acid Makes Good Producer Out of Abandoned Well."

"Mt. Pleasant, Mich.—T. K. Buzard's Mahon 1, Isabella County, Isabella Township, Section 24, a well plugged as dry several months ago, flowed 368 barrels of oil in 21 hours after being cleaned out and run with a special acid limestone solvent solution. The well made 200 barrels the second 24 hours and is continuing to flow from 100 to 175 barrels a day.

"This is the first instance in Michigan at least where an abandoned well has been re-worked with commercial success.

"In the east field of the Central Michigan proven area, Braden-Saunders' Stapleton 3, Midland County, Greendale Township, Section 13, completed in September for 210 barrels a day, was boosted to 1700 barrels a day this week when treated with the acid limestone solvent."

The Dowell Company, and previously the Dow Company, was in the business of acidizing wells during the year 1932, and they began to advertise that service in trade publications in the fall of 1932, after Dowell Incorporated was organized.

CROSS EXAMINATION

By Mr. Lyon:

Q. Mr. Putnam, what prompted these letters and inquiries from the trade which have been referred to here, an announcement by the Dow Company in some form that they had a new process? A. As I recall it it was more word of mouth than anything else.

Q. Didn't you announce in these statements that appeared in the newspapers that you had a new process? A. Well, so far as we were concerned, we did not attempt to go out and get publicity early in the oil treating business. We announced to the trade that we had a new process, at some time during the year. I wouldn't know exactly when that was. As to what we announced regarding the new feature of the process, I would want to refresh my memory by looking at some of the things we wrote up at that time. I don't remember whether or not we told the public that the thing that was new about our process was that we were adding an inhibitor to the acid, and that was the only thing that was new. As to whether or not we announced to the public that we had a new process employing a new acid and didn't even tell the public what the acid was, I would have to go back and see how we handled that. That was nearly ten years ago.

I testified before Judge Kennamer in the Williams Brothers case.

Mr. Lyon:

Judge McDermott, in stating the grounds on which he reverses the lower court, why he holds this invention says:

"Patentee expended substantial sums to demonstrate the utility of the invention before applying for the patent."

Now, as appears at page 68 of the printed record on appeal, you testified as follows before Judge Kennamer, did you not:

"I can give you a part of the cost of the plaintiff in

Sherman W. Putnam

its early development of the process in connection with the research laboratories, advertising, etc."

And you gave there testimony on which Judge McDermott based that finding. You understand that. A. Yes.

Q. You do not any longer contend that that testimony was correct, do you? A. If I so testified in the Williams Brothers case, it was correct to the best of my knowledge at that time, but it has been nearly ten years and I don't recall all the details.

Q. Well, you know, do you not, that money was not spent by the Dow Company in connection with experimenting with this inhibitor, at all, but was expended on some earlier work they had done on acidizing wells which had nothing to do with the Grebe and Sanford patent? A. Why, I couldn't answer that because you are getting into details now I am not familiar with.

Q. Well, you do not care now, you are not prepared now to repeat the testimony which you gave before Judge Kennamer and which was accepted in Judge McDermott's opinion as one of the bases on which he placed his opinion, you don't care to repeat that, to-wit, that some \$11,000 had been spent, and so forth, on this invention before—not \$11,000, but a very large sum had been spent on this invention before the patent was applied for on experimental work? A. I am very glad to repeat my testimony of that time if my memory may be refreshed.

Q. Now, had the Dow Company expended substantial sums to demonstrate the utility of the invention before the patent was applied for in June, 1932, and by the invention I refer to the addition of the inhibitor to the acid? A. If I so testified at that time, that was correct.

Q. I am asking you now to testify, had they, to your knowledge? A. Well, I don't recall now as to just what the dates, and so forth, were on that.

Calvin A. Campbell

CALVIN A. CAMPBELL,

a witness called by plaintiff, testified as follows:

DIRECT EXAMINATION

I live at Midland, Michigan, and am an attorney with the Dow Chemical Company. Head of their legal staff and one of the counsel in this case. I am not a patent attorney and look after the patent work only in a general way.

I have access to the licenses which are granted by the Dow Chemical Company. All licenses with respect, particularly, to these acidizing patents go through my office and through me personally. I have them with me.

By Mr. Owen:

Q. Will you go through them one at a time and state when each one was granted, and to whom, and if you can I would like to have you give them chronologically?

The Court:

You said something about licenses. You mean licenses under just the four patents in suit?

Mr. Owen:

No. They include the four patents in suit, and a number of others.

The Court:

You are not asking for all the licenses that they hold.

Mr. Owen:

Only the ones that include the patents in suit, licenses under the patents in suit, but those licenses—

The Court (interposing):

There are only four patents in suit?

Mr. Owen:

Yes, Your Honor.

The Court:

Then, all you are asking for is the licenses they hold under these four patents, aren't you?

Mr. Owen:

I am asking for the licenses that the Dow Chemical Company has granted to others under these patents.

A. Mr. Owen, in answering that question I assume you want the license agreements that have been granted but are not now in existence, is that correct?

Q. I would like a complete list of them chronologically whether or not they are now in existence? **A.** The first license agreement was between the Dow Chemical Company and Dowell Incorporated and was entered into on November 20, 1932. It has been superseded by a new agreement dated September 9, 1936, which is now in existence.

The next agreement is with the Pure Oil Company. The date of the first agreement between Pure Oil Company and Dow Chemical was January 1st, 1932; and that was superseded by a new agreement dated June 30th, 1934, and that agreement with Pure Oil Company dated June 30th, 1934, is still in existence. And the last dated agreement with Dowell is still in existence.

There was an agreement dated March 12, 1934, between the Texas Treating Company, a co-partnership of Dallas, Texas, and Dowell Incorporated relating to patent 1,877,504, which is not now in existence,—a license agreement under that.

The Court:

Has the Dowell Incorporated got the right to grant sub-licenses **A.** The Dowell Incorporated under its existing agreement, which is the one dated September 9, 1936, has the right to sub-license its customers under the patents mentioned in the agreement, to use the patents only in connection with materials purchased by customers from Dowell or a similar quantity purchased elsewhere. So, the agreement that Dowell made with the Texas Treating Company apparently was under a prior agreement which is not now in effect. At the present time Dowell has no right as such to sub-license under the patents other than what I have just stated to you.

Calvin A. Campbell

The Court:

You mean Dowell Incorporated has no right? A. Dowell Incorporated, that is correct. Dowell Incorporated is Dowell. That is the way we generally refer to them.

The Court:

And Dow Chemical still retains the right to license others if they want to? A. That is exactly right. The agreements I am about to read are the license agreements that Dow Chemical has made with others.

The Court:

(Interposing): That is what I thought. That is what confused me here. This third one you mentioned is a sub-license. They are sub something from Dowell? A. That is correct. That agreement is no longer in effect, however.

The next is an agreement dated August 9, 1934, between the Stanolind Oil & Gas Company, and Dowell, Incorporated, and that falls in the same category as the previous exhibit that I mentioned with the Texas Treating Company and Dowell. That agreement is not now in existence, and it expired on August 9, 1939. It was a sub-contract made by Dowell.

The next agreement is between Dow Chemical Company and Robert J. Quinlan, dated December 24, 1936, and is in existence at the present time.

The Court

That makes three I have that are still in existence. A. Yes; that is correct. The Pure Oil Company, Dowell and Robert J. Quinlan.

The next agreement is between Dow Chemical Company and the Morgan Well Treating Corporation, dated January 1, 1937, and that agreement was cancelled, or, rather, it expired as of January 1, 1940.

The next agreement is between the Dow Chemical Company and the Big West Oil Company, of Montana, dated November 15, 1937; and it expired on November 15, 1939.

The next agreement is between Dow Chemical Company and Warren Hough, of Shelby, Montana, dated June 10, 1938, and that agreement is in existence.

Calvin A. Campbell

The next agreement is dated August 31, 1938, between the Ainsworth Well Treating Service and Dow Chemical Company, and that agreement was cancelled as of January 1, 1940.

The next agreement is between Dow Chemical Company and Pacific Cementing Company, dated September 2, 1938, and that was cancelled as of October 31, 1940.

The next agreement is between Dow Chemical Company and A. G. Chiles, of Hillsboro, Texas, dated May 23, 1939, and that agreement is in existence.

The next agreement is between the Dow Chemical Company and James G. Vander Grift, of Spencer, West Virginia, dated June 30, 1939, and that agreement is in existence.

I also have three agreements which are in existence, which were entered into in 1940. The first agreement is between Dow Chemical Company and Lane & Bowler Incorporated, dated April 24, 1940. The next one is between Dow Chemical Company and Charles Theo. Eline, dated May 28, 1940, and the next and last agreement is between Dow Chemical and International Cementers Inc., dated December 4, 1940.

I forgot to mention that there is one other agreement between Dow Chemical and Dowell Sociedad Anonima dated October 11, 1936, covering license rights in Mexico, a licensee and wholly owned subsidiary of Dow Chemical Company. That is still in existence. So, as a recapitulation, I have got nine existing agreements.

The Court:

Ten, counting this last one. Ten counting Dowell Incorporated, unless I have made a mistake. A. That is correct, Your Honor. I did not include Pure Oil Company. So including Pure Oil Company there are ten.

The Court:

Six have been issued and cancelled or expired.

CROSS EXAMINATION

By Mr. Lyon:

Q. In the Pure Oil Company agreement which is in effect between Dow Chemical Company and the Pure Oil Company, there is a provision to the effect that "Dow shall pay unto Pure a royalty of \$5.00 for each and every well which shall be treated by Dow, its subsidiaries, sub-licensees, agents and representatives, provided, however, that the royalty shall not apply to any wells treated by Pure." That is correct, isn't it? A. That is the way the agreement reads, yes, sir.

Q. As a matter of fact, the agreement between Dow and Pure was reached following a dispute between Pure and Dow as to the rights to the acidizing invention, was it not?

A. This agreement that you just read from states that the contract of June 30, 1934, superseded and terminated the agreement dated January 31st, 1933.

Q. Well, the prior agreement of January, 1933, contained a provision that Dow shall pay Pure in the manner hereinafter specified a royalty of \$5.00 for each and every well which will be treated by Dow, its subsidiary, and so forth, did it not, until the royalties so paid shall amount to \$15,000? A. That is correct.

Q. There is no such limitation on the new agreement?

A. You mean about the maximum amount?

Q. Yes. The present effective agreement. A. That is correct; yes.

Q. Well, now, these two agreements, one replaces the other and they are the only two agreements between Dow and Pure on this subject? A. There is really only one agreement between Dow and Pure because the latter one superseded the former one.

Q. Yes. Well, now, the agreement was made between Pure and Dow following a dispute between the two companies as to the rights of the acidizing invention, was it not?

A. I didn't hear the latter part of that.

Calvin A. Campbell

Q. Would you just read it.

The Court:

You refer now to the first agreement or the continuing agreement?

Mr. Lyon:

Oh, to the first agreement.

(The pending question was read by the reporter.) A. I know nothing of that. It was before my time, and I don't know whether it was true or not, of my own knowledge.

Q. When did you go with the Dow Company, Mr. Campbell? A. June, '35.

Q. June of 1935. Then you are not familiar or never heard of the letter addressed to the Pure Oil Company on November 1st, 1922—or 1932, by Mr. Willard Dow, and the Pure Oil Company's reply dated December 1st, 1932? A. I think I have seen that letter, and that is all. I know nothing about it.

Q. Could you identify those letters as letters in the company files? A. I cannot identify those letters, no.

Q. Did you negotiate either of these agreements between the Pure Oil Company and the Dow Chemical Company? A. No, sir.

Witness:

I referred to an agreement with the International Cementing Company, either the Dow Chemical Company or Dowell owns an interest in the International Cementing Company, or International Cementers, Inc. I am not sure which one it is. It is either Dow Chemical or Dowell that is a stockholder in that company, and I think it is Dowell. I am not sure what percentage. They are a substantial stockholder. One of the two, and I am not sure which it is. They were one of the incorporators and organizers of the company.

The only ones of these nine existing licensees outside of the Pure Oil Company in which either Dow Chemical or the Dowell have an interest are Dowell, Incorporated, Dowell Sociedad Anonima and International Cementers. That leaves six license agreements outstanding which are

Calvin A. Campbell

held by concerns in which neither Dow nor Dowell hold any interest.

The Court:

(Interposing): What about Pure Oil?

Mr. Lyon:

That is excluded, your Honor. We have excluded that from this consideration.

So far as I know all those six concerns are actually operating under their license agreements and paying royalties at this time. The Accounting Department would know better as to whether they are actually paying royalties. They are actually actively employing the processes at this time. I know that of my own knowledge in each case.

These license agreements are not limited to the patents involved in this suit. They include other patents, too.

Q. I would like to know what patents those licenses are issued under. A. A typical example of a license is the A. G. Chiles license in which there are licensed fifteen patents, of which Dow Chemical is the owner. The licensee has also been granted license rights under two patents which Dow Chemical Company has a right to grant licenses.

Q. Does that include the Carr patent of the Pure Oil Company? A. That includes the two patents I am talking about which Dow Chemical has a right to grant sublicenses, Patent 1,891,667 and Patent 2,018,199, the first inventor being Carr and the second patent being Carr and Humphrey, inventors.

Q. Are the four patents involved in this suit of the Dow Company listed in these licenses, these six licenses, among those fifteen? A. Included in the fifteen patents in the Chiles license are the following four patents: 1,877,504, 1,916,122, 1,998,756, and 2,024,718, which I have been informed are the patents in suit.

Q. The licenses also cover eleven other issued patents by number? A. That is correct.

Q. Can you give us the numbers of those eleven other patents? A. Referring to the Chiles license, these are numbers 1,498,045; 1,911,446; 1,963,072; 1,989,479; 2,048,-

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362; 2,503,285; 2,125,429; 2,127,662; 2,146,732; 2,146,754, and 2,152,306.

By Mr. Lyon:

Q. Continuing: Do you know whether or not those are all patents on various inventions relating to the acidizing of wells? A. That is correct. That is my understanding of them.

REDIRECT EXAMINATION

By Mr. Owen:

Q. You spoke of having rights to grant licenses under a Carr patent and under a Carr and Humphrey patent. And you also spoke of paying to the Pure Oil Company \$5.00 a well royalty. Do those two things have any connection? A. The agreement with the Pure Oil Company, dated June 30, 1934, was a grant by Dow to Pure Oil Company of a non-exclusive license under 1,877,504. There was a reciprocal grant from Pure to Dow, a non-exclusive license with the right to sub-license others, under patent 1,891,667, and any other patents which Pure may acquire, own or control during the existence of this agreement and relating to the acid treatment of oil or gas wells for the full term or terms of any such patents.

The second sentence says: "Dow shall pay unto Pure a royalty of \$5.00 for each and every well which shall be treated by Dow, its subsidiaries, sub-licensees, agents or representatives after the execution of this contract, provided, however, that such royalty shall not apply to any well treated by Pure."

RECROSS EXAMINATION

By Mr. Lyon:

Q. Under that agreement the Dow Company actually has paid a royalty to the Pure Oil Company on all acidizing jobs performed by the Dowell Company or Dow, and not simply on those performed using the Carr invention, isn't

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that correct? A. That statement of yours is correct, with this proviso—that there was an amendment to that agreement, dated October 19, 1938, between Dow Chemical and Pure, reading as follows: “The royalty of \$5.00 for each and every well which shall be treated by Dow, its subsidiaries, sub-licensees, agents or representatives shall apply only on acid treatments where the acid is used to attack a productive formation.

Q. Yes. In other words, the intent of the agreement as shown by what has been done in performing it is that Dow shall pay to Pure \$5.00 on each acidizing job where the acidizing is to penetrate the formation. The payment of royalties is not limited to those jobs where Dow has employed the inventions of the Carr patents. A. That is correct.

CHARLES PENHALIGEN,

a witness called by plaintiff, testified as follows:

DIRECT EXAMINATION

I live at Midland, Michigan, and am Treasurer of Dowell, Incorporated. I have been associated with that company over five years. My duties at first were as an accountant. On January, 29, 1937, I was elected Assistant Secretary and Auditor. On June 28, 1937, I was elected Assistant Treasurer. On June 5, 1940, I was made treas-

Charles Penhaligen

urer. The records of Dowell, Incorporated, are under my charge, or accessible to me.

Mr. Lyon:

We will concede, your Honor, that they have proper records, and that they will show royalties received from jobs done, and we will concede the competency of this witness to prepare a summary from the records, and if he produces a summary and says that it is correct to the best of his knowledge and belief, we will accept that without any further proof.

The Witness:

I have prepared a summary showing the growth of the Dowell business, both with respect to personnel and stations, as well as with respect to the locations in which the company operates, and the number of treatments made, which I produce.

Mr. Owen:

This enlarged chart, your Honor, which we will offer as PX-94, contains the data which this witness has prepared. I hand the court a reduced photostatic copy of that chart.

(The chart was thereupon marked PX-94.)

The Witness:

These are the Dowell, Incorporated, statistics for the period November 10, 1932, to December 31, 1940, inclusive, by years, and this reports the personnel, treating stations, pump trucks, compressor trucks, tank transports, tank trailers, pick-ups and passenger cars; the number of well treatments, and the number of states in which Dowell operated by years. The number of well treatments indicated on this chart do not include treatments made by licensees of Dowell, or of the Dow Company. Those are treatments that were made by Dowell Inc.

The portion of the chart which indicates the states in which Dowell operates indicates the order in which Dowell or Dow operated in these respective states. Michigan was the first, then Ohio and Kentucky. Those stations were all opened in 1932. Under 1933 we have those three states repeated and in addition Kansas, Louisiana, Oklahoma and

Texas, which means that stations in those four states were opened during 1933. That explanation follows all down through until in 1940 Dowell is operating in sixteen states. Dowell also operates outside of the United States, in Alberta, Canada. I think that Dowell operated in Ontario, Canada, starting in 1932 and started operations in Alberta, Canada, in 1937. The figures indicating the number of well treatments include those made in Ontario and Alberta.

We also have records showing the number of treatments made by licensees of Dow Chemical or of Dowell. I could prepare from those records a statement showing the number of treatments made by each of the different licensees by years, on which treatments those licensees paid royalties to Dow Chemical Company, and will do so. That statement will show the number of treatments by each licensee for each year during the period for which they have been licensed, and the amount of royalty paid by each licensee each year.

Mr. Owen:

I will ask the witness whether or not he knows the fact regarding the use of inhibited acid in the well treatments which he has listed in PX-94. A. It is my understanding that these wells were treated with inhibited hydrochloric acid.

Q. Will you refer to some invoices showing the use of the surface tension reducing agent? A. Yes, sir. I have a copy of a Dowell Incorporated invoice, dated July 7, 1934, billing the Continental Oil Company, of Borger, Texas, for one Dowell treatment, consisting of 875 gallons of Dowell X, and 150 gallons of XF. The X is 15 per cent inhibited hydrochloric acid, and F is surface tension agent, the reducing agent. When the letters "XF" are used together it indicates a combination of 15 per cent inhibited hydrochloric acid, and the surface tension reducing agent.

Mr. Lyon:

Is that the earliest date of an order that you could find showing the use of a surface tension reducing agent? A. I would not say it is the earliest, but it is one of the earliest.

The Court: What about the jelly seal? A. Well, jelly seal, I don't think was used until 1935, latter part of 1935.

Mr. Owen: Can you produce evidence or invoices showing an early instance when each of these different services was used? A. Yes, sir. I have invoice instructions here, dated November 23, 1932, on which we issued an invoice to the G. Lee P. Company, Midland, Michigan, for 1,000 gallons of Dowell X and 25 gallons Dowell blanket. It is my understanding that this was the calcium chloride blanket. I have here a warehouse shipment paper, which is instructions to the Invoice Department, dated December 1, 1932, to invoice H. P. Leeper for one Dowell service treatment, consisting of 500 gallons of Dowell X and 55 gallons of Dowell blanket.

I also have a copy of a Dowell Incorporated sales invoice, dated March 12, 1936, billing the Stanolind Oil & Gas Company, Tulsa, Oklahoma, for Dowell jelly seal, base service charge of \$25.00 and Dowell jelly seal used in addition, 169 gallons, at 50c a gallon, \$84.50, and this invoice is supported by a Dowell receipt which is signed by the customer.

CROSS EXAMINATION

By Mr. Lyon:

Q. I believe you have some printed schedule of the different compounds or agents that are employed by your company in acidizing the wells, that is the agents that are added to the acids, by a series of letters? A. Yes, sir.

Q. Will you just read me that schedule? I mean, what different letters are employed and what each one of the letters stands for?

Mr. Owen:

I object to that, Your Honor, if it refers to materials other than those involved in the practice of the inventions of the four patents in suit. I can't see what relevancy it can have.

Mr. Lyon:

I want to say, Your Honor, that these treatments which are involved in this summary, Exhibit 94, include a lot of different features that are covered by patents which are not involved in this suit, so as to show that those treatments are in part based on other things that are not involved in this suit.

The Court:

I don't see any way of avoiding that. You show very properly the growth by the use of these patents but your own table shows that other patents are used along with these. Now, right as I set here right now, you see, I have no way of knowing how much that growth is due to the patents in suit, and each one of the patents in suit, or as between the patents in suit and this larger number of patents that were included there than are in suit.

Mr. Owen:

Yes; that is true.

The Court:

Now, the same chart could be used almost in a suit based on some of those other patents not in suit, you see, and I am confronted with a situation where I don't see how to avoid that inquiry being made as to what this is.

Charles Penhaligen

By Mr. Owen:

Possibly this would avoid the difficulty that I am in. As I understand it, our client is not anxious to disclose its code numbers for different treatments to its competitor, the defendant in this case. I will ask the witness to state what information he would be able to give on the subject of what different ingredients were used in these treatments which are indicated on PX-94 from an examination of the invoices or other records which you have under your control without disclosing the code number which is used by Dowell Incorporated to designate these different ingredients. A. The customer receives the information as to XX and jelly seal and W's and F's, but I don't know what the chemicals are that are used in these,—the names of these chemicals. I am not a chemist.

Mr. Lyon:

Let me ask him this question. I don't think you will object to this. Under these code numbers can you tell us about how many different things there are that are added to this acid or used in this acidizing? Do you have a schedule there of the code numbers and each code number is a different thing? If you just tell us how many of those there are, that will be a start? A. Well, I have before me a Dowell Incorporated acidizing service price schedule.

Q. And how many different items are there as indicated by different code numbers there? A. Well, it reports Dowell X, XF, XG, XR, XW and XX.

The Court:

Six.

Mr. Lyon:

Q. And which of them relate to the four patents in suit? A. I don't know what the patents are.

Q.—You looked at something else. A. I referred to this book here (indicating) X, XF, XG—

Mr. Lyon:

How many are on there? A. Seven.

Q. Well, you might give all of those seven. A. Dowell X is inhibited hydrochloric solution. Dowell F is

Charles Penhaligen

a surface tension reducing agent for use in tight or low pressure wells. Dowell G, foaming agent for use in limestone removal. Dowell W, agent which imparts emulsion prevention and wetting properties to the acid. Dowell XX, intensifying agents for use in Dolomite formations. Dowell XR, retarding agents for use in fast action limestone formations. Dowell XW, mixture of highly active acids capable of dissolving Bentonite types of mud.

Q. Now, are you able to state whether or not the total well treatments indicated on Plaintiff's Exhibit 94 contained inhibited acid? A. Yes, sir.

Q. Or rather involve the use of inhibited acid? A. Yes, sir.

The Court:

All of them? A. Yes, sir.

The Court:

I am suggesting a chart that would show wells treated with inhibited acid and nothing else. I don't know what it would show. It certainly wouldn't show the growth here, because you have got those wells as well as these using the new fangled stuff. A. True.

By Mr. Lyon:

Q. I just want the court to see the form of the Dowell invoices. This is a typical form, isn't it? (Indicating.) A. Yes, sir.

Mr. Lyon:

This is an invoice dated 3/16/36 to the Stanolin Oil and Gas Company, and the following description and prices appear on the invoice:

"Acid L. L. Austin No. 36 Well Section 36 12 16 Ellis County Kansas with 1,000 gallons of Dowell X and other materials, unit price \$225. Additional Dowell X used 2,000 gallons at 20 cents per gallon, unit price \$400. Additional for using Dowell jelly seal, base service charge \$25. Dowell jelly seal used, 150 gallons at 50 cents per gallon, \$75. Total \$725. Less 20 per cent contract discount, \$145. Amount \$580."

Charles Penhaligen

Q. Now, where these different items, of which you have given us the code numbers, were used in the service or in the treatment, they would be identified and itemized charges for those would appear, for those individual items appearing on the invoice, would there not? A. Yes, sir.

Q. Do these well treatments that are tabulated in the summary, Exhibit 94, include anything except acidizing jobs? A. No, sir.

Q. Do you know whether these well treatments up here that are summarized on Exhibit 94 include mud treatment jobs that have been done by your company? A. Well, if we used inhibited hydrochloric acid, it is included. I don't know what the technique is on the mud acid. I don't know whether they use hydrochloric acid or some other acid. I do not know what is meant by "mudding off" a well. I know we have a mud acid service. I would have to go back to the records to tell whether or not that includes hydrochloric acid.

These figures on Exhibit 94 include jobs in California. I don't know that the only service that our company performs in California is this mud dissolving, and that there is no acidizing of formations in California. At the present time we are not in California. We were in '40. I don't know that we never did acidize formations in California. I don't know one way or the other. These figures may include services performed by our company which are not acidizing formations, as far as I know. Those figures include sales invoices we have on hand that indicate we acidized the wells, using 15%—or use inhibited hydrochloric acid. Every one of these treatments included in the summary, Exhibit 94, did employ hydrochloric acid. I don't know what hydrochloric acid was employed in the jobs in California that are indicated on Exhibit 94. I don't know of the exact application. I don't know whether they were for treating formations to increase the productivity. I do know that we have a mud service operation. As to whether the jobs in California were the mud service operation or the treatment of formations, it would be necessary for me to review our records.

William F. Brown

WILLIAM F. BROWN,

a witness called by plaintiff, testified as follows:

DIRECT EXAMINATION

I live at Mt. Pleasant, Michigan, and am a consulting geologist. I received a Bachelor of Science degree from the University of Michigan in 1925 and spent a year on graduate work at the University of Wisconsin in 1926. After finishing college I worked for the Michigan State Conservation Department, The Pure Oil Company and the Cities Service Company, and since 1931 have been a consulting geologist in Michigan.

Referring to the article in the August 29, 1932, issue of the "Oil Weekly" (PX-14) relating to the Walter L. McClanahan Inc.'s Schaeffer No. 1 oil well located in Midland County, Michigan, I have examined the State production records for this well at the office of the Michigan Tax Commission for the period from July 14, 1932, the completion date of the well, to June, 1936, the date when the well was abandoned. These records are sworn statements made by the oil operator to the State of Michigan Tax Commission and are open to the inspection of the public and show that this well was completed July 14, 1932, during which month it produced a daily average of 75 barrels of oil. After being acidized, it had a daily average production of 334 barrels for August, 374 barrels for September and 234 barrels for October of 1932.

I also examined the records of the Michigan State Tax Commission and Michigan Department of Conservation concerning T. K. Buzzard's Mahon No. 1 well, referred to in the November 14, 1932, issue of the Oil Weekly (PX-14). These records showed that this well produced 381 barrels of oil in January, 1932, 538 barrels in February, and 58 barrels in March, was plugged and abandoned on March 12, 1932; reopened in October, 1932, and treated with acid, and in November, 1932, it produced 2,017 barrels of oil, and in December 2,020 barrels of oil. The well was finally plugged and abandoned in 1936.

William F. Brown

I examined the records of the geological division of the Michigan State Conservation Department concerning the oil wells in the Greendale Oil Field, Midland County, Michigan, and from them made a compilation covering the years 1932 to 1940, showing each year the number of oil wells completed, the number of dry holes, the number of wells shot (dynamited) at completion of the well drilling, and the number of wells treated with acid at completion. This compilation shows that from 1928 to 1932 the number of wells drilled in this oil field increased, and that from 1932 to 1940 the number of new wells declined. The top number of new wells completed in any year was 98 in 1932. During that year seven dry holes were drilled, three wells were shot at completion and eight were acidized. The compilation shows a decrease in the number of wells shot at completion and an increase in the number of wells acidized at completion.

The compilation was offered as PX-99, and is as follows:

COMPLETION DATA GREENDALE OIL FIELD
Greendale Twp., Midland County, Michigan

Year	Oil Wells Completed	Dry Holes	Wells acidized	
			Wells Shot at completion	at comple- tion date
1928	3	0	1	0
1929	11	2	0	0
1930	17	0	0	0
1931	26	3	1	0
1932	98	7	3	8
1933	53	8	0	4
1934	19	1	0	4
1935	14	3	0	11
1936	13	2	0	13
1937	6	3	0	6
1938	0	0	0	0
1939	1	0	0	1
1940	1	0	0	1

William F. Brown

CROSS EXAMINATION

By Mr. Lyon:

Q. This PX-14 and the data you presented a moment ago refer to the well known as T. K. Buzard's Mahon 1 Isabella County, Isabella Township, Section 24? A. Yes.

Q. You know that well? A. Yes.

Q. Do you know who acidized it? A. No.

Q. Do you know whether Dow or Dowell acidized it? A. No.

Q. I show you acidizing order to the Halliburton Oil Well Cementing Company, from Petroleum Investors, Inc. with respect to Knight Well No. 2, Section 16, Township 18 N, Range 1 East, dated 4-24-39, signed by William F. Brown. Is that your signature? A. It is.

Q. By what authority did you sign that order on behalf of Petroleum Investors, Inc.? Were you connected with Petroleum Investors, Inc., at that time? A. I have done considerable consulting work for them, yes.

Q. I have asked you the question, were you employed by them at that time? A. Not as a member of the firm.

Q. What authority did you have to sign an order, an acidizing order to the Halliburton Company on behalf of Petroleum Investors, Inc., at that time? A. I asked them for a letter giving me permission to acidize that well, and to be present and observe, and take samples on the well at the time it was acidized.

Q. Why didn't you sign the order in your own name, on behalf of yourself, if you were doing the work—if you were having the work done for yourself? A. It wasn't my well.

Q. I show you a letter on the stationery of William F. Brown, Petroleum Geologist, Mt. Pleasant, Michigan, dated April 19, 1939, addressed to the Petroleum Investors, Inc., and Doherty & Markay, Inc., Olympia Building, Mt. Pleasant, Michigan.

(Reading): "Gentlemen: Since I am desirous of ob-

William F. Brown

taining certain acid treatment information for a client, and since you are desirous of having a well treated, I agree to pay to you the full charges made by the acid treating company for the treatment of the Knight No. 2 well, located in the SW $\frac{1}{4}$ of Section 16, Hay Township, Gladwin County, Michigan.

"The conditions which I require are:

"That I choose either Dowell or Halliburton Company to do the work, specify the type of treatment, and be present during the full operations of treatment.

"Also, I shall require average daily production figures for ten days before and ten days after treatment.

"If the above arrangement will be satisfactory to you, please denote your approval below.

"Very truly yours,

"William F. Brown."

Is that your signature? A. Yes, sir, it is.

Q. Did you send that letter to the Petroleum Investors, Inc., under the date of April 19, 1939? A. I did.

Q. Who was the client referred to in this letter for whom you desired the information? A. The Dow Chemical Company.

Q. Were you authorized by the Dow Chemical Company to enter into this agreement with Petroleum Investors, Inc., whereby you could require that the Halliburton Company acidize this well of the Petroleum Investors, Inc.? A. They asked me to get certain information and to do it in the way that I wanted to.

Q. Did you reimburse Petroleum Investors, Inc., for the Halliburton Company charges for that job? A. I did.

Q. Was that money paid to you, supplied to you by Dow? A. It was.

Q. Well, now, were you present at the acidizing of that well by the Halliburton Company? A. I was.

Q. Did you pose as an employee of the Petroleum Investors, Inc.? A. I did not. It was not necessary to do so. I was merely present at the acid work.

William F. Brown

Q. In what capacity did you advise the Halliburton representative that you were attending that job—in any?
A. I don't believe they asked.

Q. You signed this order? A. If they had asked me, I would probably have said that I was doing it for myself.

Q. Where were you when you signed this order? A. At the well.

Q. You were at the well? A. Yes.

Q. How did they come to ask you to sign the order?
A. Because I ordered the acid. I was there at the complete treatment, and supervised the treatment from beginning to end.

Q. You do not deny that you posed as a representative of Petroleum Investors, Inc., do you? A. No.

Q. You did not advise the Halliburton Company that you were representing the Dow Company? A. I did not.

Q. Did you specify any of the conditions under which the well should be treated? A. I did.

Q. Did you specify that inhibited acid be used? A. I did not.

Q. What other directions did you give? A. The main directions were to put 1500 gallons of acid in the well, and to put a blanket at the bottom of the tube, and to flush it.

Q. What kind of a blanket? A. Blanket seal.

Q. What kind? A. I didn't specify. They were to use their own blanket. Then the tubing was to be flushed with oil. That is about all the instructions I gave them. Otherwise, they were to use their own regular methods of acid treatment.

Q. Did you give them these instructions in writing?
A. No.

Q. Did you specify that oil would be pumped into the well first, before the acid? A. Well, we were trying to get circulation from the tanks.

Q. Did you specify? A. Did I specify?

Q. Yes? A. I don't remember whether I did or not. I doubt it.

William F. Brown

Q. Do you remember that the oil was pumped into it?
A. Yes, oil was pumped in.

Q. Down the tubing? A. Yes.

Q. And tried to establish circulation in that way? A.
Yes.

Q. Before your acid was put in the tubing? A. It was not to establish circulation. It was more to get oil coming from the tanks. We got some oil down the hole. The tanks were setting on top of the hill, and the oil pumps were connected to the tanks, and we intended getting some oil into the tubing.

Q. You wanted to fill the tubing? A. No, we couldn't fill the tubing at that time. We didn't—you mean before the blanket or before the acid?

Q. Before the acid? A. Yes, we tried to establish circulation at that time. You are correct.

Q. And you filled the inside of the tubing and the outside of the tubing? A. We couldn't get circulation with the oil.

Q. How far did you get the oil to come back up outside the tubing? A. We put in 90 barrels of oil, or I should say Halliburton pumped in 90 barrels of oil and he couldn't fill the tubing, so Mr. King, who was supervising the acid work, stopped putting the oil in, because we couldn't establish circulation. There was no use pumping any further in. We only had about a hundred barrel on hand in the tanks.

Q. What equipment did you use in handling that oil and introducing it into the tubing? A. Halliburton's equipment.

Q. It ran through the Halliburton equipment? A.
Yes.

Q. At your request? A. Yes.

Q. That was Michigan oil in those tanks, was it not?
A. Yes, sir.

Q. Do you know whether or not Michigan oil contains mercaptans? A. No.

Q. You know what mercaptans are? A. No.

William F. Brown

Q. Do you know whether Michigan oil has a characteristic odor? A. A what?

Q. A characteristic odor, strong odor? A. Some oil has stronger than others.

Q. Well, did this oil have an odor? A. Buck oil is always quite a sweet oil.

Q. Did it have an odor? A. I could tell it was oil, crude oil, by its odor.

Q. Did it have one of these bad smells, that some of these Michigan oils have? A. No.

Q. Did you try it to see? A. I have seen a lot of it, and I don't remember that that particular well had any sour oil.

Q. You don't remember whether it did or not? A. No.

Q. Did you request that that oil be handled through the Halliburton pumps or the Halliburton equipment? A. I did not request directly, no. I asked them to give me an acid treatment in their regular way. I assumed that they would use their equipment.

Q. Didn't you ask that they pump that oil into the well or into the tubing through their pumps? A. Yes, I believe I at least conferred with them on it. I don't remember our conversation.

Q. And that oil went through that system before the acid went through the same system, did it not? A. Through the pumps?

Q. Yes? A. Yes.

Q. And when the acid was handled by those pumps, it was discharged into what? A. Into the Halliburton pumps.

Q. From the tanks? A. From the tanks.

Q. On the trucks? A. On the truck, into the pump, Halliburton pump, into the well and tubing.

William F. Brown

REDIRECT EXAMINATION

By Mr. Conner:

Q. You live in Mt. Pleasant, do you not, Mr. Brown?

A. I do.

Q. How long have you lived there? A. Since 1932.

Q. How long have you known, if at all, that Halliburton Oil Well Cementing Company have a place of business in Mt. Pleasant? A. I believe it was 1934, when I first knew the Halliburton men themselves. I think they had some equipment in before that, but I wouldn't be too sure about it. I think it was 1934 when I first—

Q. (interposing): What is your present knowledge as to the business that Halliburton transacts out of its station in Mt. Pleasant, Michigan? A. Well, I see the trucks there.

Mr. Lyon: At the present time? A. And equipment.

Mr. Lyon: There is not involved anything subsequent to the filing of this bill.

Mr. Conner: How long have you known that Halliburton in Mt. Pleasant was in the business of acidizing wells? A. I believe that was in 1934.

Q. You come in contact a great deal with operators in your work, petroleum operators, do you not? A. I do.

Q. Is it not common knowledge among those operators that Halliburton Oil Well Cementing Company operates a station at Mt. Pleasant, Michigan, and their business is acidizing oil wells? A. Yes.

Q. Is it common knowledge that Halliburton would supply the acid? A. Yes.

Q. Supply the blanket? A. Yes.

Q. Supply the surface tension reducing agent? A. Yes.

Q. Now, when such services and materials are supplied, who actually furnishes the equipment with which those materials are put into the well? A. Halliburton Oil Well Cementing Company.

William F. Brown

Q. Now, does the operator in any instance ever supply the pumps or equipment for putting those materials in the well? A. Not that I know of.

Q. I would like to have you tell the court this: In this particular treatment of this Knight well for the Petroleum Investors, the Halliburton treatment of April 24, in the year 1939, I believe, is it not— A. That is right.

Q. —did Halliburton have any way of knowing that the Dow Chemical Company was to ultimately pay for that treatment? A. Not that I know of.

Q. You didn't tell Halliburton? A. No.

Q. That Dow would ultimately pay? A. No, I didn't.

Q. Then, in this instance, perhaps you can tell us wherein the services that Halliburton rendered to the Petroleum Investors was any different than that which it would have rendered to any other operator?

Mr. Lyon (interposing): I object to that. A. I don't believe there was any difference.

Mr. Lyon: I object to that on the ground it is only within the extent of the witness's notion what their service is that he can answer.

The Court: Well, you don't claim it was any different, do you?

Mr. Lyon: Between what?

The Court: Well—

Mr. Lyon (interposing): I don't know what they are going to claim for this.

The Court: What they claim is that you treated them like anybody else over in that district, as I understand it. That is what you want?

Mr. Conner: What I am trying to show, Your Honor, is that Halliburton is in the business of acidizing oil wells, and they have equipment. They offer acid, they offer pumps, they offer surface tension, and you call them up to treat your well and they treat it the same as if I called them up. There was nothing any different because they treated this well for which we were forced to pay in order to have a man present, Mr. Brown, for the purpose of taking

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samples. There was no difference in the way it was treated.

The Court: What you want to prove is that is the way you know it was treated, and you want to show that that is their usual way of treating wells.

Mr. Conner: It is so far as we know, and I think it is up to them to show it was different, if it was.

The Court: Well, that is something particularly within your knowledge, and I will let them prove it in a pretty slipshod sort of a way.

Mr. Lyon: That is quite all right.

The Court: Because it is so easy for you to dispute.

Mr. Lyon: We may agree, Your Honor.

The Court: I thought probably—

Mr. Lyon (interposing): That there was no difference, but I want to know what they are going to say they found in these samples and what they attribute what they found to before we agree that that well was done under this witness's direction and is typical of the wells that we do in Michigan.

The Court: Well, so far as their proving it, but you don't want them to get in that that was typical until you know what they claim was in there.

Mr. Lyon: That is right.

The Court: I think you are quite right in that reservation, and I hadn't covered that phase of it. So far as his observation goes, the treatment of this was the same as any other, but he hasn't covered those items concerning which they say they might want to object. That is when you get down to the analyses.

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PAUL E. FITZGERALD,

a witness called by plaintiff, testified as follows:

DIRECT EXAMINATION

I live in Tulsa, Oklahoma, and am employed as a geologist by Dowell, Inc. I have a degree in geology from Ohio State University, have done graduate work at the University of Michigan and have been employed by Dowell since 1933. Upon leaving the University of Michigan I taught school and later worked for the Pure Oil Company as a geologist. The most important of my present duties is keeping up with developments in the various oil fields throughout the country wherein the services of Dowell Incorporated might be applicable.

I have made a study concerning the limestone well producing fields of the United States with reference to the date in which the various limestone fields in the various well producing states were discovered. This study was completed within the last thirty days. It was begun about the first week in July, 1941. It was made, according to my understanding, for the purposes of this suit. The survey is in two sections. The first section contains three parts. Part 1, or Sub-1 of the first section of the report lists the earliest limestone discoveries in the various fields throughout the United States. We give the location and the name of the field and its date of discovery. Part 2, or Sub-2 of Section 1 of the report, indicates the approximate number of fields producing oil from limestones that were discovered prior to 1932, and Part 3 shows the approximate number of the oil companies that were known to be operating in these limestone fields prior to 1932.

Section 2 of the report lists the states and shows the names of the companies that were operating in the states in fields that were discovered prior to 1932. These are limestone fields, you understand. It also shows the num-

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ber of well treatments that have been made for these various companies. This doesn't mean that these companies were operating in the state prior to '32—it only means they were operating in fields producing oil from limestone that were discovered prior to 1932.

(Here the report was offered and admitted as PX-192.)

Mr. Lyon: I object to the report and its offer as being hearsay in character. There has been no foundation for it at all as to its character, what weight can be given to it or whether it is admissible at all.

The Court: I recognize the importance of that. Your people are experienced in this, familiar with it, and if you find a few defects in it, bring it to my attention.

The Witness: The information included as part of the report, Subs. 1 and 2, which list the names of fields. That part of the report is a matter of record. There are various publications from which that information can be obtained. It is merely a historical statement of the name of the field, its location and its date of discovery.

The Court: Now, the other side can check that.

Mr. Conner: Yes, your Honor.

The Witness: The information in part 1, as to the names, locations, and time of discovery of the fields, is a matter of record. Sub. 2, or the part that has to do with the number of limestone fields that are producing in these various states, or were producing in them prior to 1932, is also a matter of record. It is published data, that is, information that is available in any publication that has to do with the history of the oil producing industry.

With regard to Part 3 of the report, that information has been secured through our various district managers and engineers throughout the areas in which we operate. We have listed in this section of the report the approximate number of companies that were known to be operating in these various fields prior to 1932. The list is not complete, because in some cases we have no way of checking exactly the names of all the companies that were operating. However, we are quite confident that the names that are listed

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in my report are correct, and this is intended only to show the more important operators.

The Court: What do I understand you to mean by that word "state," where it says, names of some companies that operated in the state prior to 1932.

Mr. Conner: If your Honor will look at the top of the page, this first page refers to Ohio, and in Ohio he gives you the limestone fields, and the date of their discovery in Ohio.

The Witness: If you will follow the report as I go through it you will find under "I" the first limestone fields, and I have listed them. The first one is the Lima, Ohio, field. It is located in Northwestern Ohio, and it occupies a large number of counties. That field was discovered in 1885. The producing formation is the Trenton limestone. The next field that I have listed here, and it is not a very important field, is the Newburg field which is in Northeastern Ohio, south of Cleveland, and it produces from the Newburg limestone and was discovered about 1915. I haven't taken the trouble to list the other limestone fields which are known to be producing and all prior to 1932. There weren't many important limestone fields in Ohio, outside of the Trenton field in Northwestern Ohio.

The Court: This is explanatory to me, since I have found out about that.

Witness: Now, there are no, as I said previously, no records of the exact number of operators that were in these fields prior to 1932, but we do know that prior to 1932 the companies listed below were known to have operated some of the important ones: Pure Oil Company, East Ohio Gas Company, Ohio Fuel Supply Company, Ohio Oil Company, and Sun Oil Company, and many others.

The next page. The next state in which oil was found in limestone is Indiana, and here we show the same outline, and again we find that the first field was the Trenton field in Northeastern Indiana, occupying several counties. It was discovered in 1886. And the next limestone discovery in Indiana was in 1893 when another limestone was discov-

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ered in Decatur County. We find from the record that there were approximately eleven limestone fields in Indiana prior to 1932, and our record of the number of companies operating in these fields prior to 1932 was only four, and among these are the Ohio Oil Company and the Siosi Oil Company.

The next state in which oil was discovered from limestone was Kansas, and that would be the third page in this report. We find that the first production of oil or gas from the limestone in Kansas was in 1888 when the Lyons gas field in Rice county was opened. The next limestone field in Kansas was the little Dexter field of Cowley County which was opened in 1903. In 1917 the famous Eldorado field of Butler County was discovered. Our records or the records that are available indicate that there were 78 limestone producing fields in Kansas prior to 1932.

The Court: Now, I notice that he is simply reading from this, which is apparent. I wonder if we couldn't save time, if there is nothing more only to do that with him, I would suggest that we let Mr. Lyon ask him any questions he wants to before night, and then have it over night to use.

Mr. Conner: There is a second part to this report which I think needs some explanation, and if Mr. Fitzgerald will explain it, why, perhaps we will not have to go through each state.

The Court: All right.

The second section of the report, beginning at page 20, lists the states and the companies in those states for whom we have acid treated wells. And these companies were operating in fields that were discovered prior to 1932. If you will take the first page of this section of the report you will notice there are three states listed, and you will notice that in Illinois we treated 99 wells. You will notice that in Illinois we have listed three companies and a miscellaneous group, and the total number of wells that were treated is 99. These wells have all been treated by Dowell Incorporated.

Q. And is it your statement that these companies here listed and under each state are operating in fields which are

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limestone fields and which were discovered prior to 1932?
A. That is right.

Q. And that is true all the way through the rest of this report? A. That is right.

The Court: And these number of wells have been treated during what period? A. Since 1932 up to the end of 1940.

For Indiana there were only 91. And in Kansas there are two pages here, but that total was 731 for Kansas. In Kentucky there were 123. Louisiana 1319. Michigan 763. New Mexico 323. Oklahoma 2293. Ohio 155. West Texas 943. North Central Texas 104. Texas Panhandle 417. The South Texas area, that is the Balgoni's Fall area, 154. Or a total for all of Texas of 1618. There were 349 treatments made in Montana and 80 treatments made in Wyoming.

Mr. Lyon interposing: Only one thing I would like to know before we adjourn, if you can tell me whether or not he has got some appendix or supplemental information to this report that shows where these different items of information came from, that I can check against the report and shorten any questions we have about it. For instance, how do you know that the Bell & Scholl Company, Item C on the first page of this report, was in business prior to 1932? How do you know that? A. Well, because I know the company and I know that they operated in Ohio prior to 1932. I do not know every one of these companies on this report. In the case of Ohio, I know all of those companies operated there. As a matter of fact, I grew up in Ohio. I did not know them before 1932.

Mr. Lyon: Well, then, what is the source of your information that they were operating in Ohio before 1932? A. I told you a while ago that I made the statement that this report was worked up in part by our district managers and our treating engineers in the field, and part of this report was compiled by them. Their original reports are available here in this city. Such work as appears in this report that I personally did not do was done under my

supervision, and I have reports from the men in the field to me which include the other data in these reports.

Mr. Lyon: Do those reports show where the other men got the data? A. No, I don't think they do, completely.

The Court: I am admitting this. I say, I am going to admit it, and the weight that I give to it will depend somewhat on what I find out about the regularity of it later on. But I am letting it in now, tonight, in order that the defendant may look it over; and I will, before I am through, find out how much they know, and what they do not know about it, and if there is anything—well, it seems that if it is pretty bad, they should have something that would show what is absolutely wrong with it, and if they—your proof to support it is so weak, and I recognize that it would cost a fortune, and take more time than I would give you to prove all that is in it, to hold you to strict evidence; so I am going to do that, but I am letting it in, and giving them a chance to dispute it, and if they do not dispute a single item, I will think that it is pretty well prepared. If they find some things in there that are wrong, I will hear about it.

The Witness: While employed by Dowell Incorporated I have engaged in the actual treatment of oil wells with acid. That work was begun in March of 1934 and later in 1934 I was sent to the Rocky Mountain area where I opened a treating station at Shelby, Montana. I was located there as a treating engineer and district manager until the close of 1934, when I was transferred back to Michigan. During that time we treated wells in the various oil fields in Montana, which included Kevin, Sun Burst, and Pondera, these fields being located near Shelby.

I have made a particular study of many fields in Montana to show the effects of acidizing. I was interested in the possible effects of acidizing on limestone and its effect on the recovery of oil and in that connection I became interested in this small Pondera oil field, which at the time when I was there had about 154 wells in it, and the field was not being pro rated. Dowell was doing all of the acidizing and it was quite easy to secure production information. In that

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connection, after my return to Michigan in December of 1934, in February of 1935 I began to make a more serious study of this field, and wrote a letter to the Stanolind Oil and Gas Company at Casper. This letter was directed to Mr. John Evans who was their petroleum engineer in the Rocky Mountain area at that time. I requested from him information relative to the effect of acidizing on their wells. I have a letter from Mr. Evans in reply, written February 19, 1935. I shall quote one paragraph from this letter:

“Acid treating on our leases in this field—” Mr. Evans is referring to the Pondera field. “—has been very profitable and has, I am satisfied, materially increased the ultimate production to be expected from those leases. The best evidence that this is true is that the wells making around a barrel per day prior to acid treatment were increased up to ten or fifteen barrels per day by the treatment and are still maintaining this increased production some six months later. Nine wells were very near their economic limit and could not have been expected to produce much more oil before being abandoned had they not been acidized.”

About a year later, as a matter of fact it is more than a year later, it was in June—May 29, 1936, I wrote a letter to Mr. Evans' successor, Mr. N. P. Huntington at Casper requesting later data and more complete information on the effect of acidizing in this Pondera field. More than a year had passed, and I was anxious to know whether these wells were holding up, and Mr. Huntington replied on June 2nd, and I shall quote one paragraph:

“To provide a picture reflecting the answers to your three questions I am attaching a sketch representing the production from our Pondera property. We operate forty-seven wells there. I estimate that acidizing has directly resulted in 80,000 barrels of oil to date, and that our ultimate recovery has thereby been increased 250,000 barrels. This latter figure is of course more in the nature of a guess than an estimate.”

The Court: What were the three questions? A. I will read the paragraph in which I stated the questions. “I am

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wondering, therefore, if it would be unethical to ask you to write me a letter outlining in a general way some of the data that you may have regarding the value of acidizing in Pondera. That is—(1) How much has the ultimate recovery of your producing properties been increased by the intelligent use of acid; (2) how much oil has been recovered as a direct result of acidizing, and (3) what is the present production as compared to production before treatment."

The Court: All right. Now read the other. A. He says: "I am attaching a sketch representing the production from our Pondera property. We operate forty-seven wells there. I estimate that acidizing has directly resulted in 80,000 barrels of oil to date, and that our ultimate recovery has thereby been increased 250,000 barrels. This latter figure is of course more in the nature of a guess than of an estimate." Then Mr. Huntington attached this curve or graph to his letter. This graph is merely a decline curve of their properties in the Pondera, beginning with 1931, extending to 1935, and it shows the production in barrels per day, and it shows acidizing in 1934, and it shows there was a change in the direction of the curve, indicating more oil was being produced following acidizing than there was before. The new curve is about a year and a quarter old. The difference between the old curve and the new curve, according to Mr. Huntington, represents an actual increase in production of 80,000 barrels for that period and that if they extend the new curve out from the point where it intersects the old curve, they will get approximately 250,000 more barrels than they would have if they had not acidized the wells.

The Court: When does the curve start? A. At the beginning of 1934 when three wells were acidized.

The Court: January 1st. A. It wasn't that early. I can't tell from this, exactly. I should say probably February, 1934—that is when 3 wells were treated, and about July or August of '34 they treated 20 additional wells.

The Court: It began what time, then, the first one? A. The first three wells were probably treated in Febru-

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ary of '34, and the additional 20 wells were probably treated in July or August of the same year.

Mr. Conner: I offer the curve referred to as PX-193, together with the letters explaining the same.

The Witness: These figures on the Pondera field in Montana with respect to production of oil from the field which I have given are production figures I got from someone else as the source. I have myself made a survey or study of the production of this field, which is reflected in the chart I have in my hand.

Mr. Conner: I offer the chart as PX-194.

Witness continuing: This chart is a decline curve of the entire Pondera oil field and it is nothing more or less than the plotting of the production data by months for the total field. I began my curve in January '33 and I kept it up to November, 1937. The curve shows, beginning in January '33, they were producing approximately 32,000 barrels per month, and that there was a gradual decline from that time down to July of 1934, when they were producing about 28,000 barrels per month. Acidizing in the field was begun in July—July 28, 1934, and there was an immediate increase in production. You must understand that during this period no new wells were drilled, so that the change in the direction of the curve must be attributed to acidizing.

Q. During which period is that you refer to? A. From the time the acidizing was begun in July of 1934. This curve moved upward very rapidly beginning in September, 1934, and in October of '34 the field was producing 34,000 barrels. In December it was producing approximately 41,500, and then the curve bobs around quite considerably. There is a big drop. There were 154 wells in the field in all. I don't know exactly when the last producing well was drilled in this field because there were no wells drilled in the field that were commercial producers during the time I was there. So I think the last producing well was drilled somewhere in the latter part of '33. I do know there were no new wells drilled during the period I was there. There were dry holes all around this little field.

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Q. And yet this curve show there was more oil produced after 1934 as a result of acidizing than there was oil produced in 1933? A. That is right.

The data on this report shown in the little boxes down at the bottom, for example, 1933, show 351,099 barrels. These figures came from the Oil Conservation Board of Montana. I have here a certified copy of a statement of the crude oil produced and refined in Montana by fields from the discovery date to June 30, 1939.

Mr. Conner: I would like to offer in evidence as PX-195, the Montana Oil and Mining Journal of Saturday, January 26, 1935.

(The document above referred to was thereupon marked Plaintiff's Exhibit No. 195.)

Mr. Lyon: May we have an understanding that in objecting to the witness' summary of his report, PX-192, that that applies to these other exhibits without being repeated.

The Court: Yes, it may.

Mr. Lyon: I mean exhibits that he is introducing with reference to that matter. The exhibit that I refer to is this large report of his.

The Court: It is of that type and your objection will apply to it.

Mr. Conner: This article, PX-195, is with reference to this same field and pool at Pondera, Montana, and the article states:

"Pondera production up 22,000 barrels.

"Use of acid boosts field production total 3,675,391 barrels.

"With no new drilling, Pondera oil field increased its production during 1934 by 22,210 barrels over 1933 according to official production figures compiled in the office of the Petroleum Conservation Board.

"This increase in production was due to the use of acid on the lime formation in these wells, chiefly during the latter part of the year.

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"The 1934 production brings the total yield of the field up to 3,673,391.74, which has been marketed for slightly more than \$3,000,000."

Q. Now, Mr. Fitzgerald, might I ask you, do you have in your possession any publications or releases or data from the Oil Conservation Board of the State of Montana which mentions acidizing? A. I have in my hand Bulletin S-1, dated November 13, 1936, published by the Oil Conservation Board of the State of Montana. This is a certified copy signed by R. P. Jackson, Secretary of the Oil Conservation Board of the State of Montana. On page 20 of this report there is a statement regarding the use of acid in Montana oil fields. I shall read this short statement.

I had nothing to do with the writing of this article and do not know who did write it. I first saw it about ten days ago, and never heard of it before. The title of the article is "Acidization." It reads:

"The treatment of zones in the Ellis-Madison contact horizon showing oil in newly drilled wells, as well as old 'stripper' and apparently exhausted wells, with hydrochloric acid compounds of various kinds has been generally most amazingly effective in stimulating oil and gas production. This is especially true in the Kevin-Sunburst field, where most of the acidation work has been done. The first record of acidizing operations appears in 1933 and from that time to December 31, 1935, the records show that 464 of the 980 producing, or 'shut-in,' wells in the Kevin-Sunburst field have been acidized, one time or more. Acid treatment of newly drilled wells apparently non-commercial converted them into prolific oil producers in most cases. Applied to old, and apparently exhausted, wells, it revived them and sometimes increased production to a level never before reached. In comparatively few instances have the results of acid treatment been disappointing to the operator. It may be noted in statistical table '1-A' that since acid treatment of wells in Kevin-Sunburst field was commenced in 1933, out of the total 84 new wells drilled during 1933, 1934, and 1935, only 15 were abandoned as initially

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dry or non-commercial, that is, slightly less than 18 per cent, whereas during the years 1922 to 1932, inclusive, out of total 1528 wells drilled, 399 were abandoned as initially dry, that is, slightly more than 26 per cent. It is also interesting to note in the same table that from 1922 to 1932, inclusive, the 'wells abandoned after producing operations' numbered 217, whereas during 1933, 1934 and 1935, only one such well was abandoned. It is not within the scope of this statistical bulletin to give a detailed history of acidizing operations in the Toole County fields or to discuss the possibilities connected with the more general use of acid in the future. If any reader should desire any further information on the subject, it is suggested that inquiries be addressed to the concerns engaged in the business of acidizing wells, to-wit:

"Dowell, Incorporated, Shelby, Montana.

"Big West Acid Company, Kevin, Montana.

"Oil Well Acid Treating Company, Kevin, Montana."

Incidentally, the Big West Acid Company and the Oil Well Acid Treating Company later became licensees of the Dow Chemical Company, and since 1937 or 1938 the Big West Company has left the field, but the Oil Well Acid Treating Company or its successor is still a licensee of the Dow Chemical Company.

The Court: Of all those that were named in there that they might write to to get the information, how many of them were already under license from the Dow? A. At the time of this article only Dowell, Incorporated.

The Court: None of those others had been licensed?

A. Not at that time.

The Court: How soon after were they? A. The Big West Acid Company became a licensee in 1937, I believe, and the Oil Well Acid Treating Company, or its successor, became a licensee in I believe 1938.

The Court: Did you have anything to do with their becoming licensees? A. No, sir. I left the Shelby area in December, 1935, and this article was published November 15, 1936.

Witness: May I read the last paper?

Q. (By Mr. Conner): And you had nothing to do with the writing or publishing of this article? A. No, I never saw this publication until you handed it to me a few days ago.

Mr. Owen: Ever hear of it before? A. I did not.

The Witness (reading): "The Oil Conservation Board regards the acid treatment of oil and gas bearing formations as the most important and valuable contribution yet made to the expansion and conservation of our oil and gas resources and its development and use under proper regulation and control is destined to be of incalculable benefit to the State of Montana and its citizens."

Mr. Conner: I offer this Bulletin S-1 as PX-196. which exhibit shall include the certificate appended to it. R. P. Jackson, Secretary of the Oil Conservation Board of the State of Montana, identifying this publication, stating the same is a certified copy.

The Court: Now, I think your objections are all right, but I will give you a chance. PX-195 is this Journal. Any objection to that?

Mr. Lyon: Yes, we make the same objection we make to all exhibits to PX-192.

The Court: That applies to both of these exhibits, 195 and 196, which I admit, and you have your objection.

Mr. Lyon: I have no cross-examination of this witness.

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ORLIN W. LYONS,

a witness called by plaintiff, testified as follows:

I studied mechanical engineering at Oklahoma Agricultural and Mechanical College for four years, and have been employed by Dowell Incorporated since August 7, 1936, first as a treating engineer engaged in acidizing oil and gas wells and then as a station manager engaged in the same work and supervising the work of others.

From July, 1937, until September, 1938, I was station manager for Dowell, Incorporated, at Borger, Texas, where my duties were to acidize and supervise the acidizing of oil and gas wells in that area for Dowell. Commencing about July, 1937, I made a study of the effects of acidizing on gas wells that were acidized by Dowell in the Borger, Texas, area. Prior to this a few gas wells had been acidized, but they were more or less unsuccessful. Dowell checked the results of the treatments it made. This was done by ascertaining from the well owner or operator the gas production of the well before and after acid treating it.

The results of this study were made public in an article I prepared entitled "Gas Well Acidizing" appearing in the September 12, 1938, issue of the "Oil Weekly."

Mr. Conner: A copy of the article is offered as PX-327.

On page 38 of the article appears Table 1 entitled "Increase in Flow Obtained by Acidizing Texas Panhandle Gas Wells." This table lists gas wells designated by the numerals 1 to 47, and for each well shows the number of gallons of inhibited hydrochloric acid used in treating the well, the number of stages used in the treatment (the production of gas from the well before acidizing, the production of gas after acid treating it, the percentage increase and the increase in cubic feet of gas from each well per gallon of acid used to treat it. For instance, example No. 1, 3,000 gallons were put in at stage 1, the production before acid was 3,000,000 cubic feet per day and after acid was 6,800,000.

Table I of the article refers to these wells only by numbers 1 to 47, and gives no data which identifies the owner of the well. I now produce three typewritten sheets marked "Table 1" and "Table 2." The information on these sheets appears to be the same as that contained in Table 1 of the article in the *Oil Weekly*, except that the typewritten sheets give Dowell's treatment number, the company name, the well name and the treatment date.

Mr. Conner: The three typewritten sheets are offered as PX-328.

This information and data as to production before and after acidizing and the identity of the well was furnished by the well owner, while the data concerning the date of treatment and quantity of acid used came from the records of Dowell, Incorporated. The data under "Treat. Number" are Dowell's Serial Numbers. The wells are listed in the order of their size, for purposes of comparison, which accounts for these numbers being mixed up. The last two columns are calculated values. The figures under "Before Acid" and "After Acid" refer to cubic feet of gas.

The well showing the greatest percentage increase on this report is Treatment No. 511 for Phillips Petroleum Company, being from 4,690,000 to 38,698,000, or 725%; the one showing the next highest increase is No. 401 for Shamrock Oil & Gas Co., being from 12,000,000 to 81,000,000, or 575%, and the third highest is No. 463 for Panhandle Eastern Pipe Line Co., being from 5,400,000 to 34,400,000, or 537%.

During the period from July, 1937, to September, 1938, Dowell, Inc., treated approximately 80 gas wells, about 40% of which were treated by me personally and the rest were treated under my supervision. During the period for which data was collected there were 67 treatments, so that there were twenty treatments not referred to in the article in the *Oil Weekly*.

As to why I didn't include those other wells in this article, I figured that that was a representative group of wells that would show the type of work that we were doing at that time, and I left out several of them because they

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were not representative wells, there were particular conditions attached that didn't make them a representative treatment. For example, in the Texas Panhandle you have a very complex formation. You have productive zones out there that are sometimes 600 feet, and in those productive zones will be scattered shale, dolomite, lime, arkosic material, and granite wash, and those wells are drilled with cable tools, and it is rather hard to collect the samples of the formation from a gas well because after you once start drilling why the cuttings blow out as fast as you drill, and they are blown out of the hole at such high velocity it is rather hard to catch your samples. And, for that reason, sometimes the drilling logs of these wells were rather incomplete, and there have been instances where all we had to go on was the company records, and some of these wells might not show any granite wash. Granite wash is granite pebbles carried down from the granite ridge in this particular formation, and it is non-acid-soluble, and it is permeable, and if your acid goes back in there there is no reaction, and you couldn't expect to get an increase in acidizing if you put your acid away in the granite wash.

The Court: What makes you put it in there, if you know that? A. If you don't know it is there, if the operator tells you here I have got a lime well, I would like to have it treated; the pay is from such and such a depth to such and such a depth. Why, you have no records of that.

The Court: Can't you believe those men, what they tell you? A. Well, you have to.

The Court: But that is what you believe for your statistics, if it is on top, and what they did get afterwards, these same men that are so untruthful? A. They are not untruthful, Your Honor. It is just the fact that they can't catch these samples, and they don't know the condition.

The Court: How do you know afterwards, then? A. Well, afterwards, if you put acid into a well, into a gas well, and it is a limestone formation, you don't get live acid back out. It is reacted acid. But in several of these treatments we found we had put acid into a non-reacting or non-

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soluble formation, because we got live acid back out of them. Then we were into either the granite wash or the arkosic zone.

The Court: You mean there wasn't any lime in there at all them? A. Well, yes. The upper section would be lime, and the bottom section where the acid would—the granite wash is more permeable than the dolomite above, and your acid is going to go where there is the least resistance to flow.

By Mr. Conner:

Q. I show you a tabulation on gas wells, and ask you to state whether or not that appears to be a complete list of some 67 gas wells, of which you made a survey, to show the effects of acidizing those wells, and state whether or not that list includes the 47 wells that you reported in your printed article in the Oil Weekly (handing document to the witness)? A. It appears to be that.

Mr. Conner: I ask that this be marked PX-329.

The Court (indicating): Now, begin at the beginning, begin at the top and go down, and I want to put a mark on the original, of those that are not in your advertising, so that I can look at them. I am marking them right on the original so if anybody else is ever interested they can look; 402 is left out. A. 407 and 399-A are all one treatment and are left out, 405 is out; also 468, 469, and 492, and all the rest, 493, 96, 97, and all down to the bottom of the page are left out.

The Court: Well, now, these numbers—now, what do these treatment numbers mean, are they the order of treatment, or what? A. That is the order. Now, you see that they are not in—they are not in line there because we treat oil wells also; these are just gas well treatments. Treatment 503 to 506 might mean we treated 504 and 505 for oil well treatment.

The Court: But these are in the order of time, this arrangement, are they the treatment numbers? A. That is correct, I am pretty sure it is. Referring to PX-328, which is the table 1 comprising the wells that I reported in my

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written article, the highest percentage of increases was 725 and the lowest percentage of increase was 29 per cent.

Referring to PX-329, the percentage increase of each of the wells that I left out was as follows: No. 374, the percentage increase was 73.

The Court: What is that figure from? A. That is taken from this sheet here showing the percentage increase of the wells that are left off of this sheet.

The Court: You did include there a 69 though and a 33, in those that you did publish? A. That is right.

The Court: And you left off a 73, which is higher than two that you have left off that I see? A. I would like to point out that these treatments are made in stages and due to the type of formation we are dealing with we had to more or less feel our way along in these treatments, and we put in one the gallons of acid to clean off the face of the pay, and then we would blow that acid out, take the dirt and the shale partings, and general impurities out of the well, and then introduce some fresh acid down and inject that out into the formation, and as a general rule the washing operation, which was the first stage, didn't show a particular increase in production, all that did was prepare the well for the subsequent acidizing stages, and so in order to tell whether we were going to do any good or not we had to put two stages of acid in there, and if the well looked as though it wasn't going to respond, we left the last stage out, we didn't go ahead and complete the treatment, and that is one of the reasons why I left out these ones here that you see are zero per cent and you will notice there are 4000 gallons—

The Court: Now, weren't all the things that you left out honest hazards of your business? You were honest in all you did, made an honest effort with all of them? A. That is right.

The Court: And these were hazards that went wrong? A. That is right.

The Court: But you left them out when you went to the advertising, and they are legitimate hazards of the busi-

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ness, they are things if you were going to do the thing over again you would run into those same troubles, wouldn't you? A. Yes.

The Court: And the man, if that treatment doesn't turn out good and they don't get rich out of it, that is a legitimate, honest answer, and, in order to show the whole picture, you need the whole sheet there, don't you? In order to just show what you actually accomplish and it is fine, it is good, but isn't that true, now, that in order to show just how much good you do and how much you don't do, you need the whole record in that part of it? A. Well, we could tell now a little more about how to do that, and we could avoid such wells as that, because the public out there is educated to what is necessary for proper acidizing, and they can keep their wells in such a manner that we have a little more data on the well before we start acidizing.

By Mr. Conner:

Q. Will you please continue and point out to his Honor the ones, starting with the wells that you left out, by treatment number, and refer to the percentage increase, if any? A. Well, there is treatment No. 402, is zero per cent increase. 407 is zero per cent increase. 405 is zero per cent increase.

The Court: Did you get any decreases at all? A. None here, your Honor.

There are 7 wells on this tabulation that show zero per cent increase, down about the middle of the second page. Commencing with the treatment No. 493, on the second page, and from there down to treatment 535, I did not include any of those wells in my printed article.

Q. Will you just run your eye over the column which says percentage increase, and read off the percentage increase of those wells that you did not include in your published article beginning with treatment 493? A. 315 per cent. 92 per cent. 126 per cent. 45 per cent. 89 per cent. 55 per cent. 63 per cent. 726 per cent. 401 per cent. 608 per cent. 957 per cent. 8 per cent. 140 per cent. 35 per cent. These were not included in my written article.

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The Court: When was that article written? A. It was written in—the rough draft was prepared in the latter part of July, or August.

Q. When were these wells treated? A. The last date I see is June 30.

Q. Were the figures on these wells available to go in the article if you had so desired, or had elected to put them in? A. They were.

Q. How does it happen that the last fifteen were left off? It looks to me as if you started to write that article, but you did not take a single one of those later ones. Have you got some explanation as to why you left out that period of time? A. The only reason I can give is that when I was preparing this, I had the list in front of me, and I took them down until I thought I had enough examples, and just took them in order, and left out the ones that I did not consider representative.

The Court: Are you sure that you had this list? I see that every one of them is left off here, which leads me to incline to think that you did not have those figures. A. I had the figures available at the time. I don't have my original data sheet here.

The Court: You have not put down in your published article a single one that you did not get an increase? A. That is right.

The Court: You have left them all out. It is not a fair showing, to make statistics in that way, and that is the reason why I do not accept it, in that way. I accept this complete one here, but that other one doesn't mean anything to me at all. I have got all I want on this one sheet (PX-329).

Mr. Conner: We are producing a complete sheet here, and I believe I asked the witness why he did not have this data before him, the list of wells, at the time he wrote the article, and he tells me, and he tells you that he did. That is all I know.

The Court: I think he is mistaken. I think he is absolutely honest, but I think he is mistaken about that. There

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is nothing that people get more mistaken about than on dates. A. I don't think I am, your Honor.

The Court: You were getting out this history up above, and then you come down here, and there are some good ones down at the bottom there, and if you had had them right before you, I am of the opinion that they would have gone in, and I think you are absolutely honest with me, but the extent to which people, when they are interested in a thing, are influenced by that, is something amazing.

By Mr. Conner:

Q. Mr. Lyons, I ask you if you have made any particular study or survey, either by actual work in the field or by study of Dowell Company records, which would reflect the time that acid is in contact with the tubing during an acid treatment of wells, and, if so, state how you made that survey, and when you made it, and where you got the information? A. Well, of course, my duties have been, in the past, to check treatment work in the office in Tulsa for treating techniques, and, of course, I did not compile any data at that time on the length of time it would take to introduce acid. The average length of time it would take to introduce acid in the well. But since this trial has started, I have had 122 treatment records sent up here on 97 consecutive Arbuckle dolomite wells in Kansas, and I have computed the—observed the length of time the acid was in contact with the tubing down those wells during those treatments.

Q. I hand you three sheets of paper and ask you if you can identify that as data taken from those 122 consecutive treatments? A. Yes.

Mr. Conner: I ask the reporter to mark these sheets as PX-330.

Q. I likewise hand you a sheet of paper and ask you if those are your calculations based on PX-330? A. They are.

Mr. Conner: I ask the reporter to mark that sheet as PX-331.

The Witness: I have in my possession the treatment

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records from which PX-330 was compiled and have computed each of those treatment records for the 122 treatments in order to identify the treatment number, the owner of the well, the well name and number and also to find from the treatment records the time that the acid was in the tubing in hours. Where the well was treated a second time I have identified that treatment record by treatment number and shown how long the acid was additionally in the tubing by hours. In the last column of PX-330 I show the total time in hours that the acid was in the tubing for each of these wells. I compiled this from our company records.

The Court: These figures are kept in the ordinary course of your business? A. They are recorded on each and every official treatment.

The Court: And there are many purposes for keeping these other than advertising purposes in your business? A. Yes, sir.

The Court: I will admit it as part of—when I find a system of records and bookkeeping that is good enough for people to rely on in their own business, I admit them.

Mr. Lyon: If the plaintiff wants to take all the time it wants in acidizing a well with its inhibitors, that has nothing to do with what the defendant does. We have the records here of what the defendant does, and they have already been referred to. What the plaintiff does has nothing to do with this case.

The Witness: PX-331 gives the average gallonage used in treating 97 consecutive Arbuckle dolomite wells, comprising a total of 122 treatments. The average gallons of acid is 1089½ gallons. Average of maximum treating pressure is 528 pounds per square inch. The average time acid was in the tubing is 7 hours 1 minute. The average internal diameter of tubing shown in this treatment is 2.66. The average length of tubing shown in that treatment is 3211 feet, and on this sheet is computed the square feet of surface area in 3211 feet, which equals 2241 square feet, equals the average internal surface of the tubing in these treatments.

By Mr. Conner:

Q. Mr. Lyons, have you had any occasion to learn what the hauling charges are in the oil fields, that is, trucking charges, and, if so, tell the court how you came to learn that and what those charges are? A. During the time when I was station manager in Pampa and Borger, Texas, why, we had occasion to hire trucks to haul extra gallonage of acid out to wells, and then at several times later on, since that period, I have had occasion to hire trucks to haul special equipment out to wells in conformity with my duties in that capacity. For a medium sized truck, the average price is around \$5 an hour. For the big, extremely heavy-duty trucks, it runs in the neighborhood of \$7.50 an hour. In my work of treating wells with acid I have had occasion to learn what the costs or charges are of pulling tubing out of a well, and the charge or cost of running the tubing back into the well. Several times in the past, in working up new treating techniques, we have had to pull tubing and lower special tools into the well, and often in going over this type of treatment with the operator, why, the cost of doing this work was weighed against what we might expect in results from the treatment, and the average figure that I remember—of course, it can vary all over the map, but the average figure would be around \$85 a day for a pulling unit and crew to run tubing. The figure will vary because of different depths of well, the different types of pulling machine, or whether the well has a rig front, or whether the rotary rig is still over the well. If you have to tie up a rotary rig to do this operation it would cost you much more. Taking that figure of \$85 for machine time and crew time, you could run and re-run tubing in a 3000 foot well in about a day, and that would be \$85.

Q. Have you read the Frasch patent recently? A. I have.

Q. You noticed therein that they proposed to use a specially prepared tubing for treating their wells under their method? A. Yes. They refer to either enamel-lined, enamel coat, or rubber-lined and rubber-coated tubing, or lead-lined, lead-coated tubing.

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Q. And, in order to use such a special tubing, you would have to run it into the well and then pull it out of the well again? A. That is right.

Q. Before you could do that, you would have to also pull your normal tubing, and after you had used your special tubing, run the normal tubing back; is that correct? A. That is correct.

Q. So you assume that you would have at least two complete pulling jobs, that is, running and pulling?

The Court: Have you made any figures or estimates on the average value of the increase in oil, as to how much you increased the well? That is, the relation that that bears to the expense, of course, is just as important as the expense item? How much did you increase the value of each well, on an average? A. The percentage increase?

The Court: No. In dollars, the increase in dollars, if you have any idea at all? A. Well, that is kind of a hard question to answer.

The Court: I know it is. You don't know how long they are going to run, of course? A. One well may make only a gallon of oil, and it is temporarily closed by treating, and you acidize out the corner area, and you open the natural flow up, and you get a fairly big well, there you have got an awful big increase.

The Court: \$85 does not mean much in the inducement proposition, or the discouragement proposition, unless I know what the stake is, do you see? In some places, and under certain conditions \$85 is an awful lot of money, but in other places it is just a bagatelle.

Mr. Conner: But there would be two pulling jobs as a minimum, each of which would cost \$85.

Mr. Lyon: If your Honor please, the point I am objecting to in connection with those figures is that they have nothing to do with the defendant, or nothing to do with anything that has happened in your district here in Michigan that the defendant has done. These are something the witness has taken from records in September, 1936.

The Court: But they throw some light on the industry

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we are dealing with. I agree it doesn't show what you have done. And the very fact it occurs before this suit started, and I am satisfied it wasn't being done for the purpose of a lawsuit, it is a record of what you do in your own business there. Just what do you claim when you show how long they had it in? Your purpose is to show that it would eat a lot of iron and use up a lot of acid?

Mr. Conner: If it is raw uninhibited acid.

The Court: Yes, that it would use up a lot of acid and also eat up iron, you show it for two purposes.

CROSS EXAMINATION

By Mr. Lyon:

Q. Let us go back to this first table that you produced, or, this first exhibit that you produced. your published article, that is PX-327. During the time that you were acidizing those gas wells out in the Panhandle, the Chemical Process Company was doing the same kind of work, were they not? A. Not during the first part of the period, to my knowledge. I think that you will find that May, 1937, was the first of the treatments included in PX-328.

It is hard for me to fix the date when the Chemical Process Company started in that field, doing that same work, but it was roughly after the first of the year in—shortly after the first of the year in 1938. However, they were in the Hugoton area in Kansas in the latter part of 1937. I am not sure that the Chemical Process Company was not there in the Panhandle acidizing those gas wells as early as September, 1937, because they may have acidized a well or two from their Hugoton station, coming across the Oklahoma Panhandle down into the Texas Panhandle at that time.

My article, PX-327, was published in September, 1938, in the Oil & Gas Journal. In the earlier issue of the same publication, of May 19th, 1938, Mr. M. E. Chapman, of the Chemical Process Company, published an article on the

same subject entitled "Acid Treating of Gas Wells to Increase Production." It covers the same general line, acidizing gas wells, as was covered in my later article. The table in the Chapman article "Partial List of Gas Wells Treated in Hugoton Area, Kansas" refers to gas wells, but not using the same methods. We used a gas load method of treatment, where they used a water load method of treatment. That means after you get the acid into the tubing then to pump it, force it down, follow it down, we use gas and they use water. We have gas compressors, portable gas compressors to build up enough gas pressure, rather, on top of the acid, to overcome the resistance to flow in the formation.

By Mr. Lyon:

Q. Did the Chemical Process Company in the Panhandle obtain comparable results to those you reported that was obtained by your company on these gas wells? A. Now, during that same period I don't recall any production figures on Chemical Process' production data.

The Court: You had seen their publication probably before you got yours out there? A. That is the first time I have seen that, that I recall, your Honor. This publication says it was presented before a meeting of the American Gas Association at New Orleans on May 9th to 12th, 1938. I was not present at that meeting. I might have seen this publication before, but I don't recall it.

The Court: I take it the competition has been pretty keen between all you people; there haven't been many of you, and it looks as though you had a battle between you; hasn't there been real competition, real keen competition? A. We certainly had competition.

The Court: I imagine you are each reading all the other says, and all the advertising? A. Well, not from my own experience.

By Mr. Lyon:

Q. Well, you know, don't you, that you have had substantial, real keen competition from the Chemical Process Company in the fields that you have been working in ever

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since you have been working for Dowell? A. That is right, there has been competition.

Q. Now, in this article, Mr. Chapman of the Chemical Process Company says this, after describing his method which you have already explained:

"By using this method a well was treated in the Panhandle of Texas in 23 minutes using 5,000 gallons of acid followed with a water load of 53 barrels. The well was allowed to be shut in 20 minutes awaiting chemical reaction. Before treatment the well had a rated potential of 16,900,000 cubic feet of gas per day. After treating, the well gauged 65,000,000 cubic feet. Samples of the spent acid solution following the treatment indicated that the acid was completely neutralized."

Mr. Owen: Now, if Your Honor please, I object to the reading of the paper into the record as evidence. If it is for the purpose of cross-examining the witness, all right, but it doesn't prove the facts stated in the document.

The Court: I think that is right. It is more advertising by a third party.

By Mr. Lyon:

Q. Now, isn't that description of the results obtained there consistent with the results that you know were obtained by the Chemical Process Company in that field, in acidizing those wells? A. Well, I can answer it this way, in that I haven't personally gone around to companies that Chemical Process treated for and asked them what their production results were. All that I would know would be hearsay.

I did not check up any of our competitors' results out there in the same manner that I checked up our own. During the time that I was out there, our competition treated very few wells, and I didn't check, actually check up on the production. I don't actually know whether they performed such an operation as they say and obtained such results as they say. I don't know anything about how long it took them to acidize the gas wells out there. As a matter of fact, I don't think I have ever seen Chemical Process

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treat a well other than if I happened to be treating a well on one location and they were on another, I might observe them tied into a well, but I have never gone and watched them treat a well.

Mr. Lyon: I would like to offer this advertisement—this article—if it is an advertisement, I suppose all these articles are written for the purpose of stimulating business, your Honor—I would like to offer this article of the Chemical Process Company, which I have identified, which was published in the Oil & Gas Journal of May 19th, 1938. The witness' Exhibit 327 was published the following September. I offer this to show that similar advertisements, similar articles had been published by others before the witness' article was published.

Mr. Owen: I object to the exhibit.

The Court: If they support theirs by testimony, and if they brought the data sheets in, why—

Mr. Lyon: I am not offering this to prove the facts stated. But I am offering to prove that such an advertisement was run by a competitor—that such an article was written and published in the same magazine before their article was.

Mr. Owen: I object to that as irrelevant and immaterial, your Honor.

The Court: I will let you mark it and put it in. I do not know what use I can make of it. We will call it DX-332.

(The document in question was thereupon marked Defendant's Exhibit No. 332.)

The Witness: The Hugoton field that that article talks about is entirely separate from the Texas Panhandle gas field. It is approximately 90 miles distant. It is a slightly different producing formation, different structure. The Hugoton field is, if I remember correctly, slightly deeper.

In these treatments which are set forth on Exhibit 329, we employed in acidizing those wells, either AD or A, I don't know which. I don't know what the material was that constituted the inhibitor.

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Referring to those wells in Kansas in September, 1936, which are listed on Exhibit 331, I was not there when those jobs were done. All I know about that is what I found in the records, except that I happened to be in Kansas during September of 1936, and I knew that we were having this type of work done. I was not personally present on those particular jobs that are included on this list. I don't know of my own knowledge about these times. I took them off some records in Tulsa. I have not had custody of those records since 1936; that hasn't been my job, to keep those records. All I know about what inhibitor was used in those 97 jobs that are referred to on Exhibit PX-331 is what I told you before.

The Court: What are these numbers that are omitted from PX-331? You started in and I find 1802, 3, 4, 5, and 1806 are missing. A. That would be either some other type of formation or some other type of treatment, that is other than Arbuckle dolomite. We are trying to compare this on one particular formation so that the wells would be more or less uniform.

By Mr. Lyon:

Q. You go down to No. 1831, and then the next number is 1848; there were 15 jobs between those numbers; what were those jobs? A. I don't know.

The Court: There are individual ones omitted. 1821 isn't there. A. Oh, yes, lots of them.

The Court: 23. All the way along they are omitted. By Mr. Lyon:

Q. What do you mean that these are consecutive? A. They are consecutive Arbuckle dolomite wells. There are all kinds of producing formations in Kansas, and we just picked one particular producing section so it would be more comparable.

The Court: When did you select those? A. Since this trial started last July.

The Court: If you used other kinds, what kind of showing would you make? A. I have no idea, your Honor. I asked the office in Tulsa to send me approximately 100 con-

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secutive dolomite treatments during this period. I could not answer that question.

I do not know that these omitted ones are not dolomite treatments. I requested this and this is what they sent me. I asked them for approximately 100 consecutive dolomite treatments. The Arbuckle dolomite is noted for its low initial permeability. I do not think that these treatments on that dolomite show an extreme example of taking a long time to get the acid to penetrate the formation and leave the tubing. I think it is a good representative showing of tight wells that we encounter in treating in several areas. As to whether this is unusual, this is as high as any. I can't answer definitely. It is high, yes. It is high. But you will notice here that the range goes from fifteen minutes—I believe I am correct in that—

The Court: Have you got a copy of your letter in which you asked for what you wanted? A. I telephoned.

The Court: Did you tell him what you were trying to prove and what the other side was claiming, so he would kind of know what he was looking for? A. In this conversation I told him I wanted approximately 100 consecutive dolomite wells, and I explained to him that I wanted the records themselves so that I could compute the treating time.

By Mr. Lyon:

Q. Didn't you want him—didn't you tell him you wanted to get a selection that would give you an average time of about seven hours? A. No, I did not.

Q. Well, these columns that are headed time, total time in hours that the acid was in tubing, or total acid—total time acid was in tubing in hours, that doesn't mean that the total amount of acid was in the tubing that length of time, does it? A. In order to figure that, you have to have some index point. And that is where—the index was taken as the bottom of the tubing, and the time was figured from the time that the acid was lowered to the bottom and until it was flushed out of the tubing. That means that that one particular portion of the tubing was in contact with the

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acid for that period of time. As to whether that means that all of this acid that was used in that operation was acting on that point of the tubing for that full length of time, it means that that point was in contact with the acid for that period of time. I do not know how to explain it in any other way. Your acid is moving down the tubing, and that point was in contact with the tubing. 1089 gallons of acid was employed in these jobs, on the average, and the average tubing depth was 3211 feet. As to how much acid that tubing will hold it all depends on the size of the tubing. I can give you the figures for this, that is, the 3-inch tubing holds 8 barrels per thousand feet; the 2½ inch tubing holds 5.7 barrels per thousand feet; the 2 inch tubing holds 4.8 barrels per thousand feet. There are 42 gallons in a barrel, and in that depth for 2½ inch tubing, it would be about 19 barrels, and that figures out about 1550 gallons. You could put 1500 gallons in a 2½ inch tubing that deep.

I have no idea what these times would be if I had these other omitted treatments here, had those included in the average. It might be higher, or it might be lower. As to what those other wells were that were omitted, all I know is that we were treating the formation known as the Chat, and we were treating the Viola, the Simpson, and the Mississippi Lime, and several other formations. We then used practically the same type of pump that we now employ.

By Mr. Lyon:

Q. I notice Mr. Chapman says in his write-up, Defendant's Exhibit 332:

Reading: "Although the pumps used in acid work are extremely efficient with regard to high volume and high pressure, operators generally favor the multi-pump hook-up. On large acid shots, two or more pumps are used to inject the acidulated fluid into the wells. Recently a well was treated in Young County, Tex., with 20,000 gallons of acid. This acid charge was followed with an oil load of 230 bbls. Ten pumps were connected and delivered fluid simultaneously. The overall treating time on this well for the acid and oil load was 59 minutes." Now, have you done the

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same thing in your work? A. I have never hooked 10 pumps up. The most I have ever used was three pumps.

Q. Well, what would be the average time that the acid would be in the well—I mean in the pipe in these 97 jobs reported on PX-330, if you omitted the ten per cent of the jobs which were the highest jobs? A. Well, there are some figures here on the back; 18 treatments were 12 hours or over, or 14.75 per cent of the total; 35 treatments were 6 hours or over, or 26.68 of the total.

Q. Well, that doesn't add up to anything; I say suppose you just take—how many of these treatments are above 25 hours, let's go through; you have said the average is 7, let's go through, there is one at 53, No. 1, one at 33, that will be 2, one at 29 would be 3, one at 55 would be 4, one at 36 would be 5, and one at 43 would be 6, one at 27 would be 8, another 27 would be 9, one at 29 would be 10, one at 31 would be 11, one at 46 would be 12, one at 31 would be 13, one at 33 would be 14. Now, I suspect if you take those 14 out of that that you have averaged in with those 97, your average time in this thing, instead of being 7 hours would be under an hour. Just look at that and see if you don't think so? A. Well, it is obvious that it would reduce it, but I don't know—

Q. Most of these figures run around, some of them half an hour and some of them one hour and one hour, one hour?

The Court: One fifteen minutes.

By Mr. Lyon:

Q. Yes. Now, if you would take these fifteen out of here, or fourteen out, what kind of a time are you going to get? A. Well, I would have to total it up and divide it out in order to answer that question correctly. Offhand, it looks like you would reduce down to in the neighborhood of 3 hours.

Q. Well, we can all do that, I suppose. Now, you don't know whether the actual times of treatment for these wells, intermediate wells, or intermediate treatments, that are not reported on this sheet, are longer or shorter than those that are reported? A. No, I don't know.

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These omitted wells in this series which is reported on PX-330 were in different formations, assuming they carried out my request. I asked for Arbuckle dolomite wells, for the reason I gave you a moment ago, it is noted to be of extremely low permeability initially. As to what formations were treated in the treatments that are omitted in the series that is noted on this Exhibit PX-330, I stated that a moment ago, that they would possibly include the Simpson and the Viola and Chat and Mississippi limestone. The Chat formation will treat a little bit easier than the dolomite. It is a little more highly reactive, and while the well may be tight to start with it shows a fairly rapid decrease in resistance to flow after the treatment progresses. The Simpson will vary depending on the locality. It may be the Simpson formation will be harder to treat than a dolomite, but it is highly variable. The Mississippi limestone is another highly variable. Some of those wells are extremely low initial permeability, and don't increase in permeability very rapidly as you progress with the treatment. The Viola is in the same class as the Chat, namely, that it increases.

By Mr. Lyon:

Q. You have referred to the cost of a tubing job as maybe being about \$85. That would be high for many tubing jobs and low for others, wouldn't it? A. That is right.

Regarding the price that the operator has to pay for an ordinary acidizing job, the minimum price for a 500-gallon job is \$175. I believe that that was the price in 1936. For a 1,000-gallon job the price is \$250. That includes the base service price, and then after you use higher gallonage, the price goes down proportionately. After you have used 1,000 gallons, the next 1,000 does not cost as much. For a 2,000-gallon job it is \$250 for the base service charge, for 1,000 gallons, and then 18 cents a gallon thereafter for the additional acid up to 5,000 gallons. An approximate figure for the average amount of acid on the jobs that are performed by our company, I would say would be between 3,000 and 4,000 gallons. A typical job

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of acidizing that is done by our company is not on an old well, that is producing maybe one or two barrels of oil a day, for the purpose of increasing it to three or four barrels a day. The trend has been in recent years to acidize new wells on completion. However, we still acidize quite a few old wells.

Q. It would be safe to say that you would not be in business, you couldn't afford to operate if what you were trying to do and the only business you had was trying to increase old wells that were down to one or two barrels a day, or three or four, up to maybe three or four times that? If that were the only possibility in the wells you would not be in business, would you? A. The answer is obvious that you wouldn't. It is a matter of economics there, and you have to qualify that by assuming the price of the oil is low.

Q. In other words, people couldn't afford to spend \$300 or \$400 for an acidizing job on the kind of wells that I mentioned? A. Well, it is purely a matter of economics, and if you can get a five-barrel increase in production that will stay up and maintain a five-barrel increase in production for a long period of time, then it is possible that that might pay a rather high rate of return on a relatively low investment. In other words, there is lots of people will invest \$200 to get \$5.00 a day back for a considerable length of time.

Q. Well, you couldn't depend on that kind of wells to run your business, could you? That is obvious? A. Well, I think the answer is "no" to that.

I do not intend by my testimony here about the cost of pulling a string of tubing, that the judge should understand from my testimony that an acidizing job is prohibitive if it is necessary to pull a string of tubing in connection with the acidizing job. Our acidizing jobs sometimes involve pulling a string of tubing, depending upon the type of treatment. Our acidizing treatments where we use an acid jet gun require the pulling or the reinsertion of a string of tubing. An acid jet gun is a tool that we have

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developed to impinge acid at high velocities against the formation, and take advantage of the erosion effect which you get from impinging the acid at high velocities in conjunction with the chemical effect that you get. The acid jet gun consists of a metal tube that has jets placed in it, 1/16th of an inch jets placed in it, 120 degrees apart, and around the barrel, one foot apart, up and down the barrel.

In using the type of tool I described it is necessary to make a special tubing run to get the tool in and to remove the tool it is necessary to pull the tubing out, but to eliminate that procedure we have developed a jet gun that we run inside the tubing and eliminate that. We did use the tool making special tubing runs commercially and charged for it and did quite a business with it, but it proved to be awkward and so we developed this other one.

As to what other types of acidizing operations where you have to pull or run a string of tubing, if you are going to use a packer to confine your acid to a certain section, if the packer wasn't a part of the well before hand, you would have to pull the tubing and put a packer on. Relatively few of the treatments are made that way. It is not an uncommon thing to do in the business of our company. It is done a good many times over the course of a year.

Q. And in all those cases you have to run a special string of tubing and remove the tubing at the end of the acidizing operation? A. It is not a special operation—it is just the tubing with a packer on it.

That is all the situations, types of acidizing jobs, done by our company in which we have to make a special tubing run that I can think of right now, other than the kind where the operator wants to clean out his well before acidizing, but we do not have anything to do with that.

Q. Well, isn't it perfectly obvious to you that if there was no other way of doing it, that acidizing would still be worthwhile, or worth enough to your customers to warrant their making a special tubing run? A. Why, in the developed state that it is now, I would say "Yes."

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Q. Isn't it true that in oil field operations the common practice is, for one reason or another, to pull the tubing in the well every few months, irrespective of any acidizing; I mean even if there is no acidizing involved?

A. Well, that of course depends upon the field conditions or well conditions. In fields that have paraffin troubles, why, they will pull tubing; sometimes they have to pull the tubing to remove the paraffin. They certainly do pull tubing and replace it occasionally in wells when they do not pump right.

RE-DIRECT EXAMINATION

I stated that I took up my duties as station manager at Borger, Texas, and the Texas Panhandle, some time in July of 1937. I do not recall that Chemical Process Company had treated any gas wells with acid in the Texas Panhandle territory prior to my going there in July of 1937 as station manager. I knew that they were operating in the Hugoton area, which is removed eighty or ninety miles from there. Our first treatment in that field using this method, according to my tables, was May 10, 1937.

When you use the jet gun in acid treatments, you must pull the tubing and put on the gun, run it back in, pull the tubing and take the gun off. The gun is so constructed that you can produce fluid if you want to leave it in the well. You have got to make two round trips to recover the gun.

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HEITHECKER STIPULATION

(Offered on behalf of plaintiff.)

It is stipulated by and between counsel for the respective parties that if R. E. Heithecker were called by plaintiff and sworn as a witness he would testify as follows:

I am a resident of Bartlesville, Oklahoma, and my address is care of the Bureau of Mines in that city. My education and experience include a Bachelor of Science degree in Mechanical Engineering from Purdue University, in June, 1924, employment in the production, refining, gasoline and purchasing departments of Empire Companies (now Cities Service Company), Bartlesville, Oklahoma, from July 1, 1924, to October 1, 1926, and employment by the United States Bureau of Mines continuously since October 2, 1926.

The Bureau of Mines was established by Organic Act of Congress (36 Stat. 369) approved May 16, 1910, effective July 1, 1910, and amended by an Act (37 Stat. 681) approved and effective February 25, 1913. An Act (40 Stat. 469) approved March 3, 1915, authorized the Secretary of the Interior to establish and maintain mining experiment and mine safety stations under the Bureau of Mines. In 1917 the Secretary of the Interior designated that one of the experiment stations should be devoted exclusively to petroleum and natural gas, and in 1918 the Petroleum Experiment Station was established in Bartlesville, Oklahoma.

My work with the Bureau of Mines has been in accordance with the provisions of the above acts and has included assignments as follows: In Laramie, Wyoming, from October 2, 1926, to July 1, 1927; in Bartlesville, Oklahoma, from July 1, 1927, to December 1, 1928; in Carlsbad, New Mexico, from December 1, 1928, to June 5, 1930; in Shreveport, Louisiana, from June 5, 1930, to March 15, 1933, and in Bartlesville, Oklahoma, from September 1, 1933, to the present. My work under said assignments has been on

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problems relative to Petroleum and Natural Gas, and for a while on the drilling of potash wells in West Texas and New Mexico.

I am the author of Bureau of Mines Reports of Investigations No. 3251, published October, 1934, entitled "Engineering Studies and Results of Acid Treatment of Wells, Zwolle Oil Field, Sabine Parish, La.," and No. 3445, published April, 1939, entitled "Effect of Acid Treatment upon Ultimate Recovery of Oil from some Limestone Fields of Kansas."

As stated in the acknowledgments of these reports, the contained data were collected by me and under my supervision from the records of oil companies, acid treating companies and state oil commissions, including reports of production filed by oil producers in accordance with the requirements of Federal and State Statutes and Executive Orders. Before publication the reports were read, criticised and approved by engineers and officials of oil companies, acid treating companies and State Oil commissions as well as by the engineers of the Bureau of Mines, and the statements contained in both said reports are true and correct to the best of my knowledge and belief.

Mr. Conner: I offer in evidence as PX-69 the report of investigations by Mr. Heithecker which is No. 3445.

(The report of investigations No. 3445 referred to was thereupon marked as Plaintiff's Exhibit 69.)

Mr. Conner: Likewise I offer in evidence as PX-70 the report of investigations No. 3251 by Mr. Heithecker.

(The report of investigations No. 3251 was thereupon marked as Plaintiff's Exhibit 70.)

Mr. Lyon: We object to those, your Honor, on the ground they are hearsay and incompetent as proof of the statements of fact contained in the reports. They seem to be based on information obtained by Mr. Heithecker from other parties, and the other parties are not here to be cross-examined. They contain many matters of opinion, as well as purported statements of fact.

The Court: I think I should stick pretty closely to the

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rule as to hearsay. All things of that kind ought to be considered with great care, in this court and all courts. So it doesn't come here in this court with any absolute presumption that they are right, I will tell you that.

The Court: I will admit these exhibits. I don't accept them as binding on this court as to what they say.

PX-69, Bureau of Mines Report on "Effect of Acid Treatment upon the Ultimate Recovery of Oil from Some Limestone Fields of Kansas," published in April, 1939, is in part as follows:

"INTRODUCTION

"In Kansas, almost every oil well drilled into a limestone formation is treated with hydrochloric (muriatic) acid upon completion. This is done to increase the potential capacity of the well and thereby increase its 'daily allowable' production (see p. 9), to shorten the time required to produce the recoverable oil, and to increase the quantity of oil recovered ultimately from the reservoir. The porosity and permeability of limestone formations seldom are uniform throughout the proved area, consequently the production capacities of completed wells vary considerably. Acid treatment of wells tends to increase production capacity and to equalize potential capacity." (Page 3.)

"If offset wells already have been treated with acid, new wells usually are treated to protect the property on which they are drilled against drainage. Even though competitive conditions do not exist in a field, it is generally assumed that the higher 'allowable' resulting from acid treatment will justify the additional cost of completing a well with acid." (Pages 3 and 4.)

"Acid treatment of wells also may be credited with extending the productive limits of some limestone fields in Kansas. Edge wells, which showed only small, non-commercial quantities of oil, have been completed as large oil wells after acid treatment, either alone or after being shot with nitroglycerin." (Page 4.)

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"Acid treating marked an advance in the producing history of limestone fields of Kansas; in fact, many old limestone fields that almost had reached their economic producing limit were 'rejuvenated' and their capacity to produce increased several times. In the Fairport field (Russell and Ellis Counties), for example, production had declined to a daily average of about 10 barrels per well, and it was unprofitable to continue to produce many of the wells. After the wells had been treated with acid, the production per well averaged over 30 barrels per day for a year, even though the production was partly curtailed through proration restrictions. The rejuvenation of the Arbuckle limestone wells of the Eldorado field, Butler County, is another example of the benefits derived from acid treatment. Many wells that had produced for 13 to 15 years and had about reached their economic limits were rejuvenated through the use of acid and continued to yield large quantities of oil." (Page 4.)

"Limestone structures that had been tested by drilling and found noncommercial were completed later as commercial oil-producing formations through the use of acid. The original development of the Kansas City limestone at Valley Center, Sedgwick County, yielded very few commercial wells, although enough oil showings were noted during drilling to deeper levels to indicate that oil was present. Evidently the low permeability of the Kansas City limestone prevented many of the wells from becoming commercial producers from this formation. After the deeper reservoir had been depleted of its economically recoverable oil, many wells were plugged back to the Kansas City formation and were made good producers by the use of acid." (Page 4.)

"Hydrochloric acid was used to treat oil wells in Kansas for the first time in October 1932. Treating programs were soon inaugurated by various oil companies; by the end of 1934, 944 wells had been treated and by the end of 1937, 5,824 wells. The total number of acid treatments given to wells in Kansas by the end of 1937 was 8,070, because many

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wells had been treated more than once. These treatments consumed approximately 12,750,000 gallons of acid. The cost of the service to the operators is estimated at about \$2,500,000." (Page 4.)

"ACKNOWLEDGMENTS

"The writer wishes to acknowledge the interest and assistance of the acid-treating service companies and of many oil companies for the generous use of their files on the acid treatment of wells in Kansas.

"Production statistics of individual wells, groups of wells, leases, and entire fields were compiled from oil-company records and from the reports of the Kansas State Corporation Commission. Well-completion records for the State were taken from the Oil and Gas Journal.

"This investigation was made under the general supervision of R. A. Cattell, chief engineer, Petroleum and Natural Gas Division; N. A. C. Smith, supervising engineer, Petroleum Experiment Station; and under the immediate supervision of W. B. Berwald, senior petroleum engineer, Bureau of Mines. C. F. McCarroll, C. R. Bopp, W. F. Krueger, and E. M. Tignor, of the Bureau of Mines, assisted in compiling the production statistics and treating records. The illustrations were traced by R. C. Wright and R. M. Himmelright.

"The writer is indebted to the following for constructive criticism of the report: L. C. Morgan, Morgan Acid, Inc.; B. M. Kingston and M. E. Chapman, The Chemical Process Co.; C. E. Clason, Halliburton Oil Well Cementing Co.; John G. Staudt and P. E. Fitzgerald, Dowell Incorporated; W. H. Burke and C. H. Keplinger, Shell Petroleum Corporation; A. W. Walker, Stanolind Oil and Gas Co.; E. O. Bennett, Continental Oil Co.; A. J. Lewis, Central Petroleum Co.; W. B. Lerch, Phillips Petroleum Co.; Sam Harlan and N. M. Hutchinson, Cities Service Co.; E. L. Rawlins, Union Producing Co.; E. G. Dahlgren and J. H. Page, State Corporation Commission of Kansas; Marvin

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Lee, Petroleum Geologist, formerly with the State Corporation Commission of Kansas; and W. B. Berwald, H. C. Miller, N. A. C. Smith, C. C. Anderson, Charles B. Carpenter, H. D. Nichols, and C. F. McCarroll, all of the Bureau of Mines.

"The investigation was carried on in cooperation with the Kansas State Corporation Commission." (Pages 5 and 6.)

"SCOPE OF REPORT

"To ascertain the effects of hydrochloric acid upon the ultimate economic recovery of oil from limestone reservoirs, it was necessary to investigate the effects of acid upon the oil reservoirs from old, depleted, or almost depleted fields, individual leases, and groups of wells." (Page 6.)

"Studies were made of the production records and production-decline curves of the wells in the Fairport field, Kansas, and one 80-acre lease in that field was studied in detail. The records of three groups of wells in the Eldorado field were examined to estimate production trends before and after acid treatment. The wells were producing from different horizons, and from the estimates of production trends the net effects of the acid on oil recovery were calculated. The records of wells in the Kansas City formation at Valley Center also were studied. Many wells were plugged back from a deeper pay, and the upper horizon was treated to obtain commercial production. Production records of the Shutts field also were examined." (Page 6.)

"Acid-treating records from the various acid-service companies operating in Kansas and those from most of the oil companies that treated some of their own wells were tabulated and classified. It is believed that the records of more than 95 per cent of the oil wells treated in the State to the end of 1937 were available for tabulation." (Page 6.)

"ACID TREATMENT OF WELLS IN KANSAS"

"Kansas oil wells were first acid-treated to increase production late in 1932, and the early treatments were very successful. Extensive acid-treating programs soon were initiated by many operators, both in old and in flush producing areas, and at present acid treatment of wells has become so general that few wells are completed in limestone formations without its use." (Page 10.)

According to the records of acid treatments, 5,824 wells in Kansas were given a total of 8,070 treatments to the end of 1937. In all, approximately 12¾ million gallons of acid were used. • • •" (Page 10.)

"FIELD STUDIES"

"The use of acid has increased the production rate of many new wells that produce from limestone formations in Kansas, but it is seldom possible to forecast ultimate yields and to demonstrate that acid treating has increased them. For new wells, however, that would have been nonproducers if they had not been acid-treated, the entire recovery may be classed as increased yields. Other wells have been plugged back to formations that previously had been tested and found noncommercial and then treated with acid. Production from such well also may be classed as increased recovery." (Page 12.)

"Oil production for the (Fairport) field reached a minimum in May 1933 shortly after the initiation of acid treatment, when 36,456 barrels of oil were produced from 123 wells, an average of 10 barrels per well per day. In November 1933, just 6 months later, the field reached a new production peak of 140,490 barrels of oil from 125 wells, an average of 37 barrels of oil per well per day. Since then the output has declined, although additional wells were drilled and several wells that had been abandoned temporarily were put back into production. In June 1938, 145

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wells produced 59,869 barrels, an average of 14 barrels per well per day." (Page 14.)

"ACID TREATMENT

"The first acid treatment of an oil well in the Fairport field was made in January 1933. Its success led to the treatment of other wells, and by the end of 1933, 95 wells had been treated. Second 'shots' of acid were given to only four wells during 1933, but during 1934 many wells received second and third treatments of acid. By the end of 1937, 260 acid treatments had been given to 175 wells, one well having been treated five times. A summary of acid treatments of wells in the Fairport field is tabulated in table 3 and shown graphically in figures 4 and 5." (Page 15.)

**"STUDY OF ACID TREATMENT ON AN 80-ACRE
LEASE IN THE FAIRPORT FIELD**

"The beneficial results of acid treatment on wells that had been abandoned or that were about ready for abandonment is shown by the study of an 80-acre lease in the Fairport field. Because of its favorable position on the producing structure, this lease probably is one of the best of the field. Eight producing wells were completed on the lease between June 1924 and February 1926 with a pattern of 10 acres per well." (Page 15.)

"In 1932, the year previous to acid rejuvenation, the lease produced 12,622 barrels of oil, an average daily output per well of $4\frac{1}{3}$ barrels. The daily average production of oil per well increased to over 7 barrels in 1933 and to 22 barrels in 1934, then declined to 12 barrels in 1935 and to $6\frac{1}{2}$ barrels in 1936. It increased to slightly over 7 barrels per well in 1937. The quantity of oil produced in 1934 compared to that in 1932 represented an increase of over 400 per cent." (Page 15.)

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“••• At the time of production test before acid treatment, 1 well was temporarily shut in and the others showed a capacity of only 2 to 7 barrels of oil daily. After acid treatment the wells tested 30 to 108 barrels of oil a day. The first well treated on the lease tested 2 barrels of oil daily before treatment and 108 barrels after treatment on January 22, 1933. No other wells on the lease were treated until November 1933, so the increase in production of oil during most of 1933 probably was due to the increase from this well. Acid treatments in other wells on the lease in November 1933 and in the early months of 1934 increased the lease output to over 5,000 barrels of oil per month for about 1 year before a decline began. In November 1934 the lease produced 6,736 barrels of oil, a daily average per well of 28 barrels. During this period, the entire field output was curtailed through proration restriction. The 24-hour potential for the lease during the greater part of 1935 was 253 barrels but dropped to 83 barrels in December. In June 1936 it was raised to 107 barrels; later in the year it was lowered to 75 barrels, holding that figure until proration was lifted in August 1937.” (Page 17.)

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"The indicated decline of oil production of the lease was rapid from February, 1935, to July, 1935. The percentage allowable for the Fairport field was reduced monthly from approximately 75 per cent of the potential rating in March 1935 to 22 per cent in October 1935. In spite of this decline, the production of the lease from July 1935 to July 1938 ranged from 1,033 to 2,518 barrels of oil monthly, which was more than it produced during the year 1932 before the wells were treated." (P. 19.)

"The cumulative production of oil at the end of 1932 was 613,277 barrels for the 80-acre lease—a recovery of 7,666 barrels of oil per acre. At the end of 1937 it was 775,325 barrels—a recovery of 9,690 barrels of oil per acre. Taking into consideration the rate of decline during the period 1927-1932, it has been calculated that by the end of 1937 the total production would have been approximately 655,000 barrels of oil if acid had not been used. Therefore, acid treatment of the wells may be credited with a net gain of at least 120,000 barrels of oil for the lease to the end of 1937, or 1,500 barrels per acre more than would have been possible under ordinary methods of production." (P. 19.)

**"EFFECTS OF ACID TREATING IN
FAIRPORT FIELD**

"The effects of well rejuvenation due to acid treatment are evident in the oil-production figures for the Fairport field. The total cumulative oil production at the end of 1932 was 7,956,263 barrels, and the well average had dropped to 12 barrels per day. If acid had not been used it is doubtful whether any of the 'temporarily abandoned' wells would have again produced oil or whether there would have been any additional drilling in the field. Considering the rate of oil-production decline from 1929 to the end of 1932, it was estimated that the quantity of oil that would have been produced from 1933 to 1937 would have been approximately 2,450,000 barrels. The actual production through the 5-year period 1933-37 was 4,956,082 barrels,

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making a net increase of approximately 2,500,000 barrels of oil. If it is assumed that no new wells would have been drilled or old wells returned to production after 1932, when acid treatment methods were introduced, the increase of 2,500,000 barrels for 125 wells is approximately 20,000 barrels of oil per well to the end of 1937. It was also estimated from the production-decline curve for 1933-37 that by about 1940 production will have declined to the average for 1932 but will not reach the older extended decline curve (1929-32) until later. From these decline curves it was estimated that during the 5-year period 1938-42 approximately 1,000,000 more barrels of oil will be produced than if acid had not been used in the Fairport field. This quantity added to the 2,500,000 barrels makes a total increase of approximately 3,500,000 barrels to the end of 1942. Considering 3,600 productive acres in the Fairport field, this quantity represents an increase of approximately 1,000 barrels of oil per acre due to acid treatment." (Pages 19, 20.)

**"ACID-TREATING INVESTIGATION IN THE
ELDORADO FIELD**

"The investigation of acid-treatment records in the Eldorado field did not include all the treatments by the different companies in all the producing horizons of the field because not enough data were available for such a study. However, the records of 266 treated wells were made available for study. These produced from three zones—the Arbuckle (Siliceous) Viola-Wilcox, and Lansing limestones." (Page 22.)

"OIL PRODUCTION

"The estimated production records of 138 wells producing from the Arbuckle (Siliceous) limestone formation which were treated with a total of 229 treatments (an average of $1\frac{2}{3}$ treatments per well) were tabulated and plotted. * * *" (P. 23.)

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"Using the rate of production decline from 1924 to 1932, graphic calculations showed that from 1933 to 1937 approximately 667,000 barrels of oil would have been produced if acid had not been used. As 2,457,000 barrels of oil were produced during this 5-year period, there was an increase of 1,790,000 barrels of oil due to acid treatment of the 138 wells to the end of 1937, an average net increase of approximately 7 barrels per day per well over the 5-year period." (Page 23.)

"A large number of wells in the Eldorado field produce from both the Viola limestone and 'Wilcox' sand." (Page 24.)

"The records show that 77 wells producing from the Viola-Wilcox formation were treated 106 times with acid—an average of $1\frac{1}{2}$ treatments per well." (P. 24, 25.)

"As a result of acid treatments of wells in the zone, the average production per well increased rapidly during 1933 from 330 barrels per month in February to 690 in December. From the peak reached in 1934, production began to decline gradually. It was estimated graphically, that approximately 1,185,000 barrels of oil would have been produced from this group of wells during 1933 to 1937, inclusive, assuming normal decline of production rates. However, as 2,324,530 barrels of oil were produced during this period, there was a net increase of approximately 1,140,000 barrels to the end of 1937, an average net increase of approximately 8 barrels per day per well over the 5-year period." (Page 25.)

"Forty-nine wells producing from the Lansing formation and two wells producing from the Kansas City limestone (which in the discussion are classed with the Lansing) received 91 treatments, an average of $1\frac{4}{5}$ treatments per well." (Page 25.)

"Using the rate of oil-production decline during 1930-32, graphic calculations showed that from 1933 through 1937 approximately 446,000 barrels of oil would have been produced if the wells had not been treated with acid. As 915,782 barrels of oil were produced during the 5-year inter-

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val, the net increase of approximately 470,000 barrels to the end of 1937 resulted from the acid treatment of the 51 wells, an average net increase of approximately 5 barrels of oil per day per well over the 5-year period." (Page 26.)

**"SUMMARY OF ACID TREATING IN THE
ELDORADO FIELD**

"Apparently acid treatment of wells in the Arbuckle (Siliceous), Viola-Wilcox, and Lansing limestone formations in the Eldorado field has increased the ultimate economic recovery of oil from these formations. It was estimated that at the end of 1937 1,790,000 more barrels of oil were produced from the Arbuckle wells than if the wells had not been treated with acid. By the end of 1942 these wells will have produced an estimated 2,690,000 barrels of oil in excess of their estimated production without acid treatment—a net increase of 19,500 barrels per well from 138 wells. This represents approximately 2,400 barrels per acre." (Page 26.)

PX-70

PX-70, Bureau of Mines Report No. 3251, entitled "Engineering Studies and Results of Acid Treatment of Wells, Zwolle Oil Field, Sabine Parish, La.," is in part as follows:

"ACKNOWLEDGMENTS

"Grateful acknowledgment is made to J. A. Shaw, director, N. V. Kinsey, former field agent, and C. P. Dunbar, all of the Louisiana Department of Conservation, as well as to the oil companies and their personnel, who have contributed well records, production data, and geological information. Credit is due the following men for their interest and assistance in the various phases of the work: R. T. Hazzard, G. W. Schneider, W. C. Spooner, H. D. Easton, Wayne Jones, S. A. Thompson, C. L. Moody, R. L. Gay and

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associates, H. E. Sullivan and assistants, E. B. Hutson, and R. D. Norton. Thanks are extended to the Standard Pipe Line Co. for production statistics and to the Gulf Refining Co. of Louisiana and the Ohio Oil Co. for well elevations.

"Acknowledgment is made to Dowell, Inc., and to the Ricou Corporation for their interest and cooperation in supplying valuable information and records showing the results of acid treatment on production. H. K. Shearer, engineer and geologist of Shreveport, La., supplied production data and information on the results of treating wells with acid, especially those operated by the Pelican Natural Gas Co." (Page 1.)

"The report was criticized by H. C. Fowler, R. A. Cattell, and H. B. Hill, of the Bureau of Mines; R. T. Hazzard, Gulf Refining Co. of Louisiana; and C. L. Moody, Ohio Oil Co. The part of the report regarding acid treatment was criticized by H. K. Shearer, Pelican Natural Gas Co.; by N. A. Best, Dowell, Incorporated; and by Ludwig Schmidt and John M. Devine, of the Bureau of Mines." (Page 2.)

"GENERAL STATEMENT

"The Bureau of Mines began an engineering study of the Zwolle oil field in June 1930 at the request of the operators and of the Louisiana Department of Conservation. Following the usual procedure in making reports on other fields geological and production data were collected. Special attention was given to obtaining information which might indicate the conditions controlling accumulation of oil in this chalk-rock field. Information also was obtained on development methods and production practices." (Page 2.)

"The pay formations in the Zwolle field are favorable to treatment with acid because of the character of the reservoir rock, which consists of chalks, marls, and limestones that dissolve readily in an acid solution. Many wells with small initial production or with favorable shows have been reconditioned by acid treatment and completed as com-

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mercial producers. Treatment of these wells with acid apparently has opened and enlarged existing, minute channelways connected with oil-bearing cavities in the chalk which readily give up the oil through the newly opened drainage channels." (Page 27.)

"PREPARATION OF ACID OR SOLVENT

"Hydrochloric acid of approximately 15-percent strength, to which certain inhibitors had been added to prevent corrosive action on well equipment, was used for treating wells in the Zwolle field. The raw acid, of 19.2° B. (1.1526 specific gravity) and 30-percent strength was shipped to the field station in rubber-lined tank cars. The inhibiting chemicals were added and mixed at the field stations while the acid to 15 percent was being diluted; the resulting solvent, of 1.07 specific gravity was stored in steel tank cars or tanks.

"The corrosive activity on metal equipment of the acid solution when properly mixed with inhibitors has been studied in detail and discussed in published articles.* For proper protection of well equipment the acid should be inhibited sufficiently to allow storage in steel tanks with a minimum of corrosive action. In treating the average well in the Zwolle area the solution is in contact with well equipment a relatively short time, and the complete operation requires only about 2 hours. Proper inhibition is a safety measure and protects the equipment against unforeseen delays which may arise during the treatment of wells. (P. 28.)

*Petroleum World, Chemical Treatment of Wells a Major Development: December, 1932, p. 511.

Oil and Gas Journal, Development of Acid Treatment of Oil Wells Involves Careful Study of Problems of Each: Feb. 23, 1933, p. 8.

Petroleum Engineer, Acid Treatment of Oil Wells: April, 1933, p. 24.
Oil Weekly, Acid Treating for Increasing Oil Production: May 29, 1933, p. 18.

“GENERAL PROCEDURE FOR TREATING WITH ACID

“The same general practice was followed by the different contractors in treating wells in the Zwolle field, namely, the solution was pumped into the formation near the bottom of the hole through a string of pipe. In pumping wells the acid solution was pumped down the tubing after removing the sucker rods and standing valve. In other wells either the drill pipe or a string of tubing was used. The procedure is described as follows:

“The casing and tubing (or drill pipe) were filled to the top with oil; the acid pump, mounted on an automobile truck, was then connected to the tubing and the solvent pumped down the hole. When the gage on the acid pump or tubinghead indicated a slight pressure, the valve on the casinghead was ‘cracked’ to allow the oil to ‘bleed’ from between the casing and the tubing. A measured amount of oil equivalent to the volume of the tubing plus the volume of the open hole from the bottom of the well to a determined point below the casing seat, was allowed to bleed from the valve; the valve was opened enough to keep the pressure from building up more than a few pounds per square inch, as indicated on the pressure gage. When the predetermined amount of oil had been bled off the valve was closed and the complete acid charge pumped into the bottom of the well. A pressure of 600 pounds per square inch was built up in some of the wells. The speed of the pump was regulated to prevent the pressure from building up higher than 600 pounds per square inch, although the pumping equipment was capable of developing pressures up to 1,500 pounds per square inch. For example, the amount of oil that could be bled from the casing was approximately 16 barrels (672 gallons) in a well 2,500 feet deep, with the casing set at 2,300 feet and equipped with a string of 2-inch tubing. Sixteen barrels is equivalent approximately to two-thirds of the acid charge.” (PP. 28, 29.)

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"The charge of 1,000 gallons was followed by 10 to 50 barrels of oil, which was pumped down the conductor pipe to displace the solvent and act as a flushing agent to clean the walls of the tubing. Some excess oil was forced into the formation, thus driving the solvent ahead of it. It was the general practice to allow the acid to remain in contact with the formation 48 hours before a production test was made."

"Pressure gages were placed generally on both the tubing and casing-heads. The gage on the tubing in one well under treatment showed a pressure of 120 pounds per square inch compared with a pressure of 375 pounds per square inch on the casing-head. On another well the pressures observed were 400 pounds on the tubing and 650 pounds on the casing. The differences in pressure between tubing and casing recorded in the two wells were 255 and 250 pounds per square inch, respectively. These figures represent approximately the difference in pressures between the 2,500-foot fluid column of acid solution (1.07 specific gravity) inside the tubing and the oil column (0.818 specific gravity) behind the tubing. The pressure at the bottom of the hole was of the order of 1275 pounds per square inch in the first well mentioned and 1,550 pounds per square inch in the second. The gage pressures varied considerably at the different wells, and higher pressures were required in the wells drilled through tight or unbroken strata than in those completed in porous or broken formations. The average time required to pump a 1,000-gallon charge of solvent ranged from 30 minutes to 2 or 3 hours, depending upon the pressures necessary to force the acid back into the formation. Siphoning of the acid solution from the acid truck into the well was observed during the second treatment of the Supreme Oil Co., Pruitt well 1, in sec. 30, T. 8 N., R. 11 W., where a charge of 1,000 gallons was run into the well in twelve minutes." (P. 29.)

"In a letter to the writer H. K. Shearer, engineer and geologist of the Pelican Natural Gas Co., has described in detail acid treatment and results of the treatment of the

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Pelican Natural Gas Co., Louisiana Long Leaf Lumber Co. well 16, in sec. 10, T. 7 N., R. 11 W." (P. 29.)

"This well was completed at a depth of 2,627 feet on November 2, 1932, and the casing was set at 2,438 feet. The production for the first day was 60 barrels, then the average daily production ranged from 8 to 12 barrels until December 8, when the well was shut down preparatory to treatment with acid. The rods and standing valve were pulled. The casing and tubing were then filled with 71½ barrels of oil. Sixteen barrels of oil were bled from the casing while the solvent was being pumped into the tubing. The casing pressure 'built up' to 250 pounds per square inch while the acid solution was being pumped into the well, but no tubing pressure was recorded. Following the acid charge of 1,000 gallons, 12 barrels of oil were pumped into the tubing. During this operation a pressure of 150 pounds per square inch was recorded on the tubing, while the casing pressure remained constant at 250 pounds per square inch. After a relatively short time the pressure on the casing and tubing dropped suddenly, suggesting a partial vacuum at the wellhead, as the acid solution flowed into the formation." (PP. 29, 30.)

"The production test began at 3:45 p. m. December 12, about 48 hours after the acid had been pumped into the well. During the first 1½ hours the well pumped 33 barrels; this was followed by 154 barrels in 4½ hours and 376 barrels in 12 hours. The production for the next 24 hours was 666 barrels. The complete production history of this well from the date of completion to January 1, 1934, is given in figure 11." (P. 30.)

"On December 28, 1933 the accumulated production from this well was 110,987 barrels, of which only 336 barrels was produced before acid treatment on December 10, 1932. Assuming that the well would have continued to produce an average of 8 barrels daily until December 28, 1933, it would have produced 2,848 barrels, in addition to the 336 barrels, or a total of 3,184 barrels without acid treatment. The difference between 110,987 barrels and 3,184 barrels is

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107,803 barrels, an amount that reasonably may be credited to acid treatment." (P. 30.)

"The increase in production of this well after acid treatment apparently had no appreciable effect on the production of the offset wells. The location relative to nearby wells is shown in figure 11. The unusual increase in production after treatment suggests that a channelway was opened by the acid to an undrained and distinct oil-filled cavity or porous zone." (P. 30.)

"The history of acid treatment of C. H. Tuttle, Byrd No. 3 well, in sec. 7, T. 7 N., R. 10 W., is of interest. The owner and Charles Frink, field representative of Dowell, Inc., gave the writer an account of the treatment. The well was completed September 1932 at a depth of 2,727 feet. The 6-inch casing was set at 2,424 feet. After it had been equipped for pumping the production was approximately 1 barrel of oil per day. The well was treated by the owner with 100 gallons of raw hydrochloric acid without an inhibitor in an attempt to increase production. The raw acid was poured into the tubing and followed by about 50 barrels of oil. A gas pressure of about 60 pounds per square inch was held on the well for approximately 5 days. The treatment resulted in an estimated increase of 8 to 10 barrels per day. In attempting to treat the well later with inhibited acid the tubing was found to be damaged so badly by the treatment with raw acid that it was impossible to pump the inhibited acid into the well under pressure. Some of the acid, however, was forced to the bottom of the hole, and upon bailing some increase in oil was noticed." (P. 30.)

"A new string of 2-inch tubing was run and the well treated the third time. The casing and tubing were filled with oil. The bleeder valve at the casinghead was opened when the acid pumps were started. After an amount of oil equal to the volumes of the tubing and the open hole up to a point near the casing seat had been bled from the casing the valve was closed and the remainder of the acid pumped into the well under pressure. The pressure at the pump immediately built up to 225 pounds, with pressure of 460 pounds per square inch at the casinghead. The acid pump,

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was run at full speed while pumping in the remainder of the charge; the pressure at the tubinghead increased to 275 pounds and that at the casinghead to 510 pounds. After approximately three-fourths of the charge had been pumped into the well the pressures dropped suddenly to 125 pounds on the tubing and 360 pounds per square inch on the casing. Following the acid 45 barrels of oil were pumped into the well to flush the tubing and drive the solvent into the formation. The pressures equalized at 300 pounds per square inch on both the tubing and casing heads when the well was closed in for 48 hours. Upon opening for a production test the well began to flow. At the end of the first 12 hours it was producing 38 barrels per hour through a one-eighth-inch choke with 175 pounds back pressure. The choke was adjusted to obtain a production of approximately 200 barrels per day. The 'closed-in' pressure was 700 pounds per square inch. The production from this well declined rapidly." (PP. 30 and 31.)

"RESULTS OF ACID TREATMENT

"An analysis of the production data covering 134 acid treatments in 113 wells showed that the oil production was increased in 62 wells for 30 days or more and that the records of 29 of the wells showed an increase in production of 100 per cent or more for a 30-day period or longer. Forty-one wells, with a combined production of 1,055 barrels per day before treatment, showed a production of 3,902 barrels per day, immediately after treatment, and 2,974 barrels per day after 30 days. The total production of the 41 wells, 30 days after treating, was 282 per cent of the amount before the acid was used. Ten wells had a combined production of 71 barrels per day before treatment, 1,782 barrels per day immediately after treatment, and 1,512 barrels per day (21 times the production before treatment) at the end of a 30-day period. The results of 134 acid treatments are given in table 12." (P. 31.)

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"CONCLUSION

"The acid method offers favorable possibilities for reviving oil production, especially in unprofitable pumping wells, and as a 'last chance' in testing 'oil showings' in newly drilled wells. At least a dozen wells in the Zwolle field have been equipped for pumping and placed upon production following the acid treatment that otherwise probably would have been abandoned as noncommercial wells."

"The additional cost of treating a newly drilled well, if warranted by oil showings, does not add materially to the total cost. To January 1, 1934, 623 wells were drilled in the Zwolle area; of this number 361 or 58 per cent were dry holes. Oil showings were recorded in many of these dry holes, some of which might have been treated successfully by acid solution. The seemingly complex reservoir conditions and the irregular occurrences of the oil in the marl and chalk formations preclude definite statements as to the results that might have been obtained in the treatment of the dry holes."

"Although the percentage of oil-well completions in the Zwolle field has remained low since the introduction of acid treatment in December, 1932, the ratio of the number of oil wells completed to the total number of tests drilled has increased from 39.5 per cent for the 13-month period before December 1, 1932, to 47.6 per cent for the 13-month period after December 1, 1932."

"It is possible that the lack of success in some examples of treatment may have resulted from insufficient amount of acid to dissolve the 'limy' deposit on the liner, which in some instances has ranged from one-fourth to three-eighths inch in thickness. It may be advisable to condition wells which are making water for a period of time before treating by pulling the liner and cleaning out the calcareous deposition and sludge material that may have collected in the bottom of the hole before acid treatment, so that the chemical action of the acid will become

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more effective in opening new drainage channels or establishing better flow conditions in the old channels after this conditioning."

"In a few wells outstanding results have been obtained by treating with acid. The somewhat spectacular increase in production from these wells has been the stimulus for the general application of the method. It has been used at some time in the majority of the wells."

"At least 150 wells were given 190 acid treatments during the 13 months ended January 1, 1934, at a cost of about \$50,000 to the operators. Based on an estimated production of 604,000 barrels of oil due to acid treatment, the return was approximately 12 barrels of oil per dollar expended. During this period the range of the posted price of crude oil was from \$0.25 to \$1.01 per barrel; and the average, weighted on a daily basis, was \$0.66." (P. 35.)

MILLER STIPULATION

(Offered on behalf of plaintiff.)

It is stipulated by and between counsel for the respective parties that if H. C. Miller were called by plaintiff and sworn as a witness, he would testify as follows:

I am a resident of San Francisco, California, and my address is care of the United States Bureau of Mines in that city. I am Senior Petroleum Engineer with the United States Bureau of Mines at San Francisco, and have been connected with said Bureau continuously for the past

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sixteen years. I am a graduate of the Michigan College of Mines, now known as the Michigan College of Mining and Technology, and have Bachelor of Science and Engineer of Mines degrees from said college.

I was sworn and testified as a witness at one of the hearings held before a sub-committee of the Committee on Interstate and Foreign Commerce of the House of Representatives of the Seventy-sixth Congress of the United States, held at Washington, D. C., on November 6, 7, 8 and 10, 1939. The following statement appearing at pages 369 and 370 of the Official Report of said hearings, printed by the United States Government Printing Office for the use of said committee, correctly summarizes my said testimony:

“Almost every well drilled into a limestone formation is treated with hydrochloric acid at some time during its producing life. In areas where daily allowable production per well is based upon the well's capacity to produce and operators desire high initial production rates so that their allowables will be maximum, acid treating usually is part of the well-completion process. In old producing areas, treating wells with acid is for the main purpose of increasing the quantity of oil recovered ultimately from the reservoir. For that reason, wells often are treated with acid at frequent intervals throughout their producing lives.

“Acid treating has had a far-reaching effect on the petroleum industry in that it has effected a complete change of attitude toward limestone production. The spread of development into such limestone areas as western Kansas, Michigan, Illinois, and northern Louisiana may be ascribed in large measure to the success of acid-treating processes. Many wells drilled into limestone formations in those areas have been commercially productive of oil and gas only as a result of acidizing. In the newly developed Illinois Basin, for example, many wells drilled into the McClosky formation—an oolitic limestone of varying porosity—failed to show as much as a drop of oil until the formation had been treated with acid. Acid treatment of wells also is credited with extending the productive limits of

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many oil fields in which edge wells incapable of producing commercial quantities of oil have been completed as paying oil wells after acid treatment. Furthermore, many fields in limestone areas that had almost reached their economic producing limit have been rejuvenated and their capacity to produce oil increased by treating them with acid.

"Acid treatment of wells to increase the productivity and ultimate recovery of oil and gas is now generally accepted as standard production practice in Michigan, Kansas, Ohio, Illinois, Kentucky, Oklahoma, Texas, and Louisiana, where oil is found in reservoirs of calcareous and dolomitic rock. In some of these areas acidizing has replaced well shooting; or, where the productive limestone formations are very dense, acid treating is used in combination with shooting to increase the production of oil and gas from wells.

"According to Heithecker,⁽¹⁾ acid treating has caused marked increase in the ultimate oil recovery of some old and nearly depleted fields of Kansas, owing to cleaning-out action of the acid at the face of the limestone, enlargement of the small drainage channels, and probably penetration of the acid into previously undrained porous strata. Estimates of greater ultimate oil recovery of various groups of wells in Kansas show increased oil recovery of 10,500 to 21,700 barrels per well, and the increased recovery per acre is estimated at 1,000 to 2,400 barrels of oil; all this has been accomplished by the additional cost of only a few hundred dollars per well for acid and treating service.

"Although it is known that 1,000 gallons of 15-per cent hydrochloric acid will dissolve about 1,800 pounds or 11 cubic feet of limestone rock, there is no definite rule to govern the quantity of acid to be used for treating an oil well. In some wells a single treatment of 1,000 gallons of acid has been beneficial in increasing the rate of flow of oil into the well and in others, according to Heithecker,⁽²⁾

(1) Heithecker, R. E., *Effect of Acid Treatment upon the Ultimate Recovery of Oil from Some Limestone Fields of Kansas*. Bureau of Mines Rept. of Investigations 3445, 1939, p. 41.

(2) Heithecker, R. E., Work cited in footnote 98, p. 5.

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as much as 24,000 gallons of acid (volume equivalent to three large railroad tank cars) have been used during stage or multiple treating, the first charge usually being 4,000, the second 8,000, and the third 12,000 gallons.

"The practice of acidizing wells has grown phenomenally in the past five years, and at present about 10,000 wells are treated annually, requiring approximately 25,000,000 gallons of acid.⁽³⁾ The rapid development of acid treating in recent years may be ascribed to the development of means for minimizing the corrosive action of the acid on casing in the well, improved technique by contract service agencies, and far-reaching results in increased oil production.

"Acid follows the path of least resistance in a well and sometimes enters depleted or thief zones and stimulates the flow of water into the wells. As it is desirable to confine the action of the acid only to the oil-bearing formation organic gels sometimes are used to control and adapt the treatment to special well conditions. This is accomplished by blanketing or plugging with organic gels the formations that acid is not to contact. The organic material is mixed with a type of bacteria to form a colloidal suspension that is pumped into the well ahead of the acid. Within one-half hour the suspension jells, and the well then is acidized while the troublesome formations are protected by the jelly plug. Within 24 to 48 hours, depending on the temperature in the well, the jellylike substance is consumed by the bacteria and liquefied so that it can be bailed, swabbed, or pumped from the well."

The statements contained in the foregoing summary of my testimony before the House Committee were then true and still are true, to the best of my knowledge and belief.

Mr. Lyon: Now, if Your Honor please, one of these special features that he refers to, this jellifying material and all of that, it doesn't seem to me the testimony given

⁽³⁾ Kiessling, O. E., Rogers, H. O., and others. Technology, Employment and Output per Man in Petroleum and Natural Gas Production. WPA National Research Project, in cooperation with the U. S. Bureau of Mines, Report No. E-10, July, 1939, p. 150.

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by this man before this Committee in Congress is admissible in this case here. We have had no opportunity to cross examine.

Mr. Conner: If Your Honor please, we were placed in the position of calling this witness, which we agreed to do, and which we would still do. Counsel, as of May 3, 1941, entered into this stipulation, signed by Mr. Babcock and myself, that he would so testify if he was called. Now they complain of the lack of ability to cross examine.

The Court: I will let it stand. I recognize if he were here I would be asking him well, how much does that inhibitant do? What would happen if you didn't have it? But he isn't here and I can't do it.

Mr. Wilber Owen: I don't know whether Your Honor noted this statement in the testimony of this man Miller. He said: "The rapid development of acid treatment in recent years may be ascribed to the development of means for minimizing the corrosive action of the acid on casing in wells, improved technique by contract service agents, and far-reaching results in increased output."

The Court: If he were here, I would ask him what he meant by "may be." Whether he means he may have been told that, whether it isn't true, or whether it should be ascribed to that. I don't know. I would ask him, any way, if he were here. I think that is a big thing in the lawsuit, gentlemen.

Erle P. Halliburton

ERLE P. HALLIBURTON,

a witness called by plaintiff, testified as follows by deposition:

DIRECT EXAMINATION

I reside at 19 Berkeley Square, Los Angeles, California, and am general manager of the Halliburton Oil Well Cementing Company. I have been connected with the defendant company since its organization in 1924 and have been its president all of that period. John C. Halliburton is my brother.

The office of the defendant company has been located at Duncan, Oklahoma, at all times since its organization. I would say that the oil industry was responsible for the organization of the Halliburton Oil Well Cementing Company, and that I promoted the organization of that company. At the time of the organization of the company, I owned a controlling interest in the stock, and have at all times either owned or controlled a majority interest in the stock.

I have taken an active interest in the operations of the company at all times since its organization and have been in as close touch with its operations as one individual could. The company was primarily organized for the purpose of cementing and servicing oil wells. Additionally, we controlled wild wells, furnished a general pumping service with our equipment, worked on wild wells and fishing jobs. By wild wells, I mean wells that got out of control, such as those that blew out. By cementing, I mean the use of cement to seal off formations encountered in the drilling of oil wells, the plugging back of wells, and squeezing the formations of wells with cement.

The Halliburton Oil Well Cementing Company has never owned or drilled any wells, or produced any oil. The company's business is rendering the services I mentioned to others who owned and operated the wells and, as time has passed, we rendered additional services.

Erle P. Halliburton

I, as an individual, had interests in the oil business prior to the date of the organization of the Halliburton Oil Well Cementing Company. Before the organization of the defendant company I engaged in cementing oil wells, and acted in a consulting capacity as an engineer, and drilled a dry hole or two for myself. Before the organization of the defendant company I had owned some small interests in oil wells.

I was engaged in the cementing of oil wells for seven or eight years prior to the organization of the defendant company, both as an individual, as a partner and as an employee of the Perkins Oil Well Cementing Company. So I was pretty thoroughly familiar with the oil well industry and the oil producing industry prior to the time that the defendant company was organized, and had actually worked in the oil fields in California, Texas, Oklahoma, Arkansas, and Louisiana. Some of these oil fields were lime and some were sand. The wells in Oklahoma were lime. I do not believe that at that time any lime formations had been opened up in Louisiana. There had been lime wells drilled in Texas but not in the fields in which I had worked.

My work in the cementing business brought me in touch with the production end of the oil business to the extent that I had put wells on production, but had never really been connected with the actual production of oil. I had worked around and on wells from the time that they had started until they were put on production; that is, began to produce oil commercially. These were wells on which I did cementing, and I have gone in and killed wells where the water broke into the well that had been on production and cemented these wells, that is, shut the water off and then supervised the drilling of the well to put it back on production.

Subsequent to the organization of the Halliburton Oil Well Cementing Company I organized the Steen Drilling Company that drilled a few oil wells. This company operated in Texas and Louisiana, and I don't remember just what official position I held, but I think that I was presi-

Erle P. Halliburton

dent. The Steen Drilling Company was organized in 1930 or 1931 and was a Delaware corporation. It was a stock company and I owned control of the stock. This company is not now in existence, as it was discontinued about four or five years ago after operating for some three or four years. E. A. Steen was vice president and Phillip Shumway was secretary-treasurer, and I think I was president of the company. This company drilled a few wells in Louisiana, but their principal operations were in east Texas, and we also drilled wells in south Texas; I think the company drilled one well at Port Lavaca, Texas. The company drilled perhaps forty or fifty wells altogether. I would not know the character of the producing formations in the territory where this company drilled. In east Texas, I know the formation was sand. The company did its own drilling and I don't remember that they contracted with others for the drilling of any wells.

I have been connected with another company engaged in the production of oil, Erle P. Halliburton, Inc., which was incorporated about 1933 or 1934. Erle P. Halliburton, Inc. owns production and took over the Steen Drilling Company's production. This company started in the production of oil maybe a year or two after its incorporation. It did not do any producing of oil prior to the time it took over the Steen Drilling Company. It may have drilled a well or two in Oklahoma in 1933 or 1934. I think that about 1933 we drilled some wells at St. Louis, Oklahoma, and I think that it took over the Steen Drilling Company some time after that. The oil wells at St. Louis, Oklahoma, were limestone wells.

Erle P. Halliburton, Inc., has been engaged in the production of oil continuously since its drilling of the wells in the St. Louis, Oklahoma, district. This business has not been very extensive. I have been president of Erle P. Halliburton, Inc. since it was organized. My wife has been a vice president, R. J. Wilbern has been a vice president, John Halliburton has been assistant secretary-treasurer, and James Coe Halliburton has been a vice president. I

Erle P. Halliburton

have been active in the control of the operations of the Steen Drilling Company and Erle P. Halliburton, Inc. I have been at the head of the business. Sometimes I am afraid I did not keep in as close touch with the business as I should have, but I did endeavor to keep in close touch with the business. Erle P. Halliburton, Inc. is now producing oil in the East Texas field. I think that is the only place that we now have any production. We contracted the drilling of a few wells in Oklahoma, Kansas and Texas. We do have a little production around Houston, Texas, in what I believe they call the Liberty Field.

By Mr. Owen:

Q. In your early experience as an oil producer, what if any method did you follow in attempting to restore production of a well which had been a paying producer, and which had fallen below a point where it would pay? A. It would depend upon the condition of the well and the nature of the formation being produced, as to what you would do, or what was causing the production to decline.

Q. Prior to 1932, did you of your own knowledge know of any instance where the production of a well in lime formation had been increased by any kind of treatment, after its production had decreased for a time? A. You mean the use of acid in the well?

Q. I mean any kind of a treatment that you know of, of your own knowledge, which was applied to a well to increase its production, in lime formation, from lime formation, prior to 1932? A. You mean chemical treatment or mechanical treatment, or what kind of treatment?

Q. Oh, any kind of treatment that you know of. A. Yes, I have re-drilled wells, lots of them, prior to that time.

Q. Just what would you do in re-drilling them? A. Sometimes drill them deeper to a lower horizon, and sometimes plug them back and drill down and shut the water off.

Q. Were any of those in lime formation? A. Some were, yes.

Q. Do you know of any other treatment that was applied to oil wells producing from lime formation, for the purpose of increasing their production? A. Yes.

Erle P. Halliburton

Q. What were the other methods you have known of?

A. I have known of shooting methods.

Q. Explain that. A. Well, take a lime formation and shoot it with gelatin, nitroglycerine, break the formation.

Q. And was that a common practice prior to 1932?

A. Yes, I had seen it done prior to that.

Q. Can you name any other method known to you to have been applied to oil wells for the purpose of increasing their production from lime formation, prior to 1932? A. I had heard of methods, but I had had no personal contact with doing it myself.

Q. You have named all those that you had any knowledge of? A. No, not all that I had any knowledge of. As a matter of fact, I had heard of the use of acid prior to 1932; in fact used acid in a well prior to that time.

Q. When did you first use acid in a well prior to 1932?

A. Either in December 1919 or January 1920.

Q. Did you do that yourself, in your own operations?

A. I did it under contract for E. H. Royer, in the Hewitt Field in Oklahoma.

Mr. Lyon: If your Honor please, if I remember correctly about that, Mr. Halliburton had no records of that particular transaction, and it was related to getting out drill pipe or tools that had been stuck in the well and using the acid to cut that limestone, or whatever it was, that would stick in the pipe or tools, and as we have so many record cases in our evidence, proof of that with full records, we didn't think it was necessary or there was any use of developing just an oral recollection of that, because we have so many of the same things in our evidence.

The Court: That explains why you didn't ask him about it, and I am satisfied.

Q. Have you named all of the methods known to you to have been used on an oil well for the purpose, or with a view to increasing its production, from lime formation, prior to 1932? A. No, I have known of flooding and vacuum, putting vacuum on the formation. I had also heard of putting heating agents, either chemicals or steam, to

Erle P. Halliburton

dissolve the paraffin and open up the formation for increasing production.

Q. You have named several. Flooding was one. What do you mean by flooding? A. In which you run water into one well and drive the oil to other wells.

Q. What was another one that you named? A. Putting a vacuum on the sand, with vacuum pumps.

Q. That is on sand formation? A. Well, on lime, or any well where vacuum would work.

Q. And how would you do that? A. Well, seal a well up tight at the top, with tubing in the well, and take the production out through the tubing, and maintain a vacuum in the casing, outside the tubing.

Q. What was one of the others that you named? A. I named the use of heat to dissolve paraffin and clean a well out.

Q. Just how was that done? A. Sometimes chemicals were used, and in some cases run steam into the well.

Q. When you used chemicals it was with the view of having or producing heat from chemical reaction in the well? A. Yes.

Q. Do you say that the use of one or more of these various methods you have mentioned was common among oil producers prior to 1932? A. In some fields, shooting was common, and in some fields different methods. You take wells that paraffined up, it was common practice to remove the paraffin in some manner.

Q. Would it be correct to say that the particular treatment which promised the best results in a particular field was the one used there? A. Well, of course different operators would try different things. Of course some producing zones gave up the oil rather freely and the wells never gave any trouble; and then there would be wells in a field where maybe one out of a dozen gave a lot of trouble, and the other wells didn't give any trouble.

With respect to the oil fields in which I have operated either directly or through my companies, it would be hard to say what the average cost of drilling a well would be.

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Up to the present time, I have spent anywhere from \$3,000 or \$4,000 up to \$150,000 on a well. With such an investment in a well, it was a natural thing for any operator to do whatever he could to increase or restore production of oil.

I think about 1933 was the first time the Halliburton Oil Well Cementing Company acidized a well. I don't know exactly who we acidized the first well for, and I don't think there was any record kept on the first wells we acidized. I think the first well we acidized was in Burkburnett in 1933. I am not sure as to that date.

Q. Do you know who owned it? A. I don't remember now who owned it.

Q. And you have no record of that treatment? A. No, I don't have any record.

Mr. Owen: Mr. Babcock, has the company any record of that treatment?

Mr. Babcock: Yes, you have got a copy of it. It is referred to in the Chamberlain-McPherson interference. My recollection it was July, 1933, and it was the King Royalty.

The Witness: Yes, that is right.

Not having been on the job and not knowing the nature of the formation, I wouldn't know about the first oil well producing from a lime formation which the Halliburton Oil Well Cementing Company treated with acid for the purpose of increasing its production. For me to state this would be purely hearsay because I didn't go out on any of these jobs.

By Mr. Owen: Will you refer to such documents or reports as you may have, relating to acidizing treatments of oil wells by the defendant company during the year 1933, or the year 1934, or at any earlier date, and point out the first one in which the defendant company gave an acidizing treatment to an oil well which was producing from lime formation, for the purpose of increasing its production?

Mr. Babcock: I have here some acidizing tickets and invoices which have come out of the file of the Halliburton

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Oil Well Cementing Company. I do not know whether these are the first—whether these tickets are on the first well done by the Halliburton Oil Well Cementing Company or not. These (indicating) are all our records that I have been able to find up to, I believe, May 1935.

Mr. Owen: And will you state how many different jobs those represent?

Mr. Babcock: Well these invoices are attached to tickets Nos. 1004, 1005, 1006, 1007, 1008, and 1009, and the earliest date is that of ticket 1004, which is March 2, 1935.

By Mr. Owen:

Q. I hand the documents to the witness and ask him to examine them and state which of them relates to an acidizing treatment of an oil well in a lime formation, for the purpose of increasing its production? A. These documents do not state the kind of acid used, or the nature of the formation that was being acidized, but I assume that all of them were lime formation. One of these apparently was not intended to increase production, but was for freeing stuck drill pipe.

Q. Which number is that? A. It is ticket No. 1006. Tickets Nos. 1004 and 1007 also refer to treatments for the recovery of stuck drill pipes.

Ticket No. 1005 shows that the formation was siliceous lime. Ticket 1008 does not seem to disclose the nature of the formation, but I would assume it was a lime formation that was acidized to increase its production. Ticket No. 1009 reports the treatment of a well which apparently was of a limestone formation. I would assume that the formations of the wells referred to in tickets Nos. 1005, 1008 and 1009 were limestone formations. I have no knowledge of these treatments aside from what appears on the acidizing tickets. I think that Joe Verser would have knowledge of these treatments, as I notice his name appears on all three of the tickets Nos. 1005, 1008 and 1009. He would have knowledge of all three of these treatments and the fact that his name appears on them indicates to me that he was present at the treatments. Ticket No. 1005 is the earliest

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and is dated March 11, 1935. Ticket No. 1008 is dated May 25, 1935, and ticket No. 1009 is also dated May 25, 1935. These tickets say they used acid and I would assume that it was hydrochloric acid. None of the wells referred to in tickets Nos. 1005, 1008 and 1009 were owned or operated by me or any of my companies.

I think that the Erle P. Halliburton, Inc., records are located in the Houston, Texas, office and not in this office, and that the Steen Drilling Company records are located here, at Houston, Texas, and at Los Angeles, California. I have no personal knowledge concerning any purchases of hydrochloric acid made by either the Steen Drilling Company or Erle P. Halliburton, Inc., from Dowell, Incorporated. I do not know whether or not the Steen Drilling Company or Erle P. Halliburton, Inc., purchased acid from Dowell, Incorporated.

Prior to the treatments of wells reported in acidizing tickets 1005, 1008 and 1009, I think we pumped hydrochloric acid into wells to free stuck tools and drill pipe, but I don't think we have any records earlier than these tickets where we put hydrochloric acid into limestone formations to increase production, and I don't know of any earlier records.

Mr. Owen: And counsel, I understand, doesn't know of any.

Mr. Babcock: None other than you already have. There is a report on that St. Louis well in that same interference file there which you already have.

Mr. Owen: Can you refer to that one, Earl?

Mr. Conner: Here it is, August 1, 1934.

At this point PX-19, 20 and 21, Halliburton Oil Well Cementing Company acidizing tickets Nos. 1005, 1008 and 1009 and the data attached thereto, were offered and received in evidence.

By Mr. Owen:

Q. I show you a purchase order of Erle P. Halliburton, Inc., No. 1234, a typewritten letter dated June 16, 1934, addressed to Dowell Incorporated, Shreveport, Louisi-

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ana, and signed in typewriting "Jack Halliburton" and a letter on Halliburton Oil Well Testing Company stationery dated July 22, 1934, addressed to L. A. Prince, Dowell Incorporated at Midland, Michigan, and signed "Erle P. Halliburton, Inc., by Harry E. Hanson," and ask you to examine them and state if you know what they refer to. A. Well, one of the documents is a purchase order, No. 1234, for 1500 gallons of acid, Barr No. 2; I think that was in Louisiana. The other two documents are letters stating where the charge should be made for the purchase of acid. Apparently Dowell Incorporated acidized the Barr No. 2 well with the acid for the Steen Drilling Company.

I do not know who owned those wells, whether Erle P. Halliburton, Inc., or Steen Drilling Company owned them. I think perhaps Erle P. Halliburton, Inc. owned the wells and the Steen Drilling Company drilled the wells for Erle P. Halliburton, Inc., under a drilling contract and Dowell Incorporated did the acidizing job for Erle P. Halliburton, Inc. Jack Halliburton was not working for Erle P. Halliburton, Inc. I think he was working for the testing department at that time. That was just a partnership, Erle P. Halliburton Company instead of Erle P. Halliburton, Inc.

I think that Dowell Incorporated acidized that well on which the acid was used, but I have no personal knowledge of that fact, as I was not on the job. The basis on which I state that Dowell Incorporated acidized the well is because of the purchase order. The order says a 1500-gallon acid job, and I would assume that Dowell Incorporated did a little more than furnish the acid; they must have furnished some equipment with which to pump the acid into the well.

I have examined a purchase order on the stationery of Erle P. Halliburton, Inc., No. 4618, and it appears to be a purchase order for acidizing a well. The order was issued to Dowell Incorporated at their Shreveport district and was signed by Jack Halliburton, and my testimony regarding this purchase order would be the same as that regarding the other order No. 1234, to which I have referred. This last order, No. 4618, looks like the Burkitt No. 3 well. It

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indicates that the acid was purchased from Dowell Incorporated for use in connection with the treatment by Dowell Incorporated of one of our wells. I have examined three documents on the stationery of Dowell Incorporated entitled "Bulk material sales receipt," these being receipts Nos. 2081, 2320, and 4513. No. 2081 indicates that we purchased a thousand gallons of acid from Dowell Incorporated. No. 2320 would indicate that we purchased 100 gallons of acid from Dowell Incorporated and bulk material sales receipt dated December 16, 1934, No. 4513, would show that Erle P. Halliburton, Inc., purchased 200 gallons of acid from Dowell Incorporated. I don't know what the acid indicated in these purchase orders was used for. The orders do not give the well number. I should imagine that the acid was used in acidizing some well some place. In the case of such a small quantity of acid as 100 gallons, the acid may have been used to get cement out of a pump.

Here is an Erle P. Halliburton, Inc. purchase order, No. 4509, Dowell Incorporated's order No. 2320, which would indicate that the acid was used at the Bang No. 2 well, and apparently Dowell Incorporated acidized that well.

Mr. Owen: The purchase order No. 1234 and the two letters attached thereto are offered as PX-23, 24 and 25; the purchase order No. 4618 is offered as PX-26; the receipt for acid, No. 2081 is offered as PX-27; the purchase order No. 4509 and the receipt attached thereto, No. 2320 are offered as PX-28 and 29, and the receipt for customer's order No. 4513 is offered as PX-30.

The Witness: I recognize the signatures on these exhibits and they are those of Jack Halliburton, who was connected with Erle P. Halliburton, Inc. at that time.

I have examined what purports to be an agreement between Steen Drilling, Inc. and Dowell Incorporated, and it is apparently an agreement between Steen Drilling, Inc. and Dowell Incorporated, whereby Dowell Incorporated is to acidize two wells located in Sabine Parish, Louisiana. This agreement was signed by Jack Halliburton on behalf of Steen Drilling, Inc. Jack Halliburton was apparently sign-

Erle P. Halliburton

ing agreements for the company at that time and I guess he was authorized to do this.

(The agreement was offered and received in evidence as PX-31.)

I have examined what purports to be an agreement between Steen Drilling, Inc. and Dowell Incorporated dated April 20, 1934, and it looks like an agreement to have Dowell Incorporated acidize wells for Steen Drilling, Inc. in Louisiana. The agreement is signed by Jack Halliburton on behalf of Steen Drilling, Inc., and I recognize his signature.

(The agreement was offered and received in evidence as PX-32.)

I have examined another agreement dated April 20, 1934, between Steen Drilling, Inc., or Erle P. Halliburton, Inc., and Dowell, Incorporated, to which is attached a carbon copy of a letter dated July 2, 1934, from Dowell, Incorporated, to Steen Drilling, Inc. This is apparently an agreement to employ Dowell to acidize ten or more wells located in Louisiana, Oklahoma, Kansas, Texas, and New Mexico, within twelve months for Steen Drilling, Inc., or Erle P. Halliburton, Inc.

Mr. Lyon: You mean this is to take the place of PX-32, dated April 20th?

Mr. Owen: That is the fact. PX-32 says ten wells in Sabine Parish, Louisiana, and was with Steen Drilling Company alone. And this other was substituted and made with Steen Drilling or Erle P. Halliburton, Inc., and instead of confining it to Louisiana it includes these other states.

The copy of letter from Dowell, Inc., to Steen Drilling, Inc., was offered and received as PX-33, and the substituted agreement was offered and received as PX-34.

Mr. Lyon: Was the contract ever performed, Mr. Owen?

Mr. Owen: Yes, it was.

The Witness: I have examined what purports to be another agreement between Erle P. Halliburton, Inc., and Dowell, Incorporated, for the treatment of a well. This ap-

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parently was an agreement entered into between Erle P. Halliburton, Inc., and Dowell, Incorporated, for acidizing a well in the St. Louis field in Oklahoma, and was signed on behalf of Erle P. Halliburton, Inc., by Paul Halliburton.

At this point carbon copy of a letter from Dowell, Incorporated, to Steen Drilling, Inc., dated July 22, 1934, was offered and received in evidence as PX-35, and the agreement last referred to between Erle P. Halliburton, Inc., and Dowell, Incorporated, dated May 10, 1934, for the acidizing of one well in Pottawatomie County, Oklahoma, was offered and received in evidence as PX-36.

The Witness: Halliburton Oil Well Cementing Company is not denying that Dowell acidized wells for Steen Drilling, Inc., for Erle P. Halliburton, Inc., for Gulf, and for a lot of companies.

The first acidizing of wells, in limestone formations for the purpose of increasing their production that I knew of on what we might call a continued commercial basis was information that I secured from different engineers in Tulsa, Oklahoma, about what the Pure Oil Company was doing. Then, soon after that, I heard The Dow Chemical Company was acidizing wells. After that I believe that Mr. Plummer of the Pure Oil Company called me and wanted to know if I wouldn't go into the business of acidizing wells.

I don't remember that I knew just where the Pure Oil Company wells were located. I knew of the use of hydrochloric acid on lime formation, and I had heard it discussed for several years even prior to that. But in these discussions, it was thought that it would be too expensive for the results obtained. I do not know that the first information that I had of actual acid treatments of oil wells was in connection with wells owned by the Pure Oil Company. The first wells that I heard of being actually treated with acid belonged, I think, to the Gypsy Oil Company. I believe an engineer working for them by the name of Wright was down here on some mud problem, and we discussed it. I talked with him personally about the use of acid. I think he said that through the Mellon Institute, the Gulf and

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Gypsy Company or some of their affiliated companies had done some experimenting on acidizing.

I would not know the exact date of the first actual information I received regarding the acidization of wells by The Dow Chemical Company or by Dowell, Incorporated, but I would say that this was perhaps in 1933 or 1934. I certainly would have known about it whenever and if they advertised it. I kept in touch with what was going on in the way of developments in the oil industry and a lot of things that were not developments.

I knew that oil wells owned by companies in which I was interested as controlling stockholder had been and were being acidized by The Dow Chemical Company or by Dowell, Incorporated. I think I knew that we acidized a few wells along in 1934, but I do not know to what extent, and I think I knew that we had employed Dowell to do this work, but I didn't discuss the details of the work with the field organization. On the first job or two I did make an effort to ascertain the details regarding these treatments and the results of the treatments.

Mr. Owen: I have here a number of other papers relating to oil wells which were acidized by Dowell, Incorporated, either for Steen Drilling, Inc., or Erle P. Halliburton, Inc. In order to shorten this portion of the deposition, I will identify these documents, and hand them in their entirety to the witness, and ask him to state what he cares to regarding them.

The Witness: A. The documents would indicate to me that Dowell did acidize the wells, about the dates indicated by the documents.

Mr. Owen: I will ask counsel whether any question will be made regarding the fact that these wells were treated by Dowell for Steen Drilling, Inc., or Erle P. Halliburton, Inc., as indicated in these documents PX-Nos. 37 to 66 which have been identified.

Mr. Lyon: We will waive further proof of these facts, subject to either party having the right to correct the record, if the necessity for any correction appears.

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(Thereupon PX-37 through PX-66 were offered and received in evidence.)

Q. Did you know on August 1, 1934, what Dowell inhibited acid was, or did you know anything about it? A. I had known for a long time that hydrochloric acid could be inhibited, and naturally I knew what they were attempting to do.

My first experience with the use of inhibited acid was with the Southwest Shipbuilding Company in 1916 or 1917. We used inhibited acid in cleaning steel castings in San Pedro, California.

I don't remember that I made any effort to ascertain what inhibitor was used in the Dowell acid. I do not know whether or not we had the Dowell acid analyzed in our laboratory.

Mr. Lyon: As I understand it, Mr. Owen, there is no issue in this case that the defendant employed inhibited acid up to some time in January, 1936.

The Witness: I am president of both Erle P. Halliburton, Inc., and Halliburton Oil Well Cementing Company. Some of the holdings of the Halliburton Oil Well Cementing Company are in the name of Erle P. Halliburton, Inc., and I think some of the holdings are in my own name. I would not remember what proportion of the stock of the Halliburton Oil Well Cementing Company is owned by Erle P. Halliburton, Inc., but Erle P. Halliburton, Inc., owns most of the stock in the Halliburton Oil Well Cementing Company. I have at all times owned or controlled a majority of the stock in the Halliburton Oil Well Cementing Company.

I would say that George Hoisington had supervision and charge of the acidizing department when the defendant company first went into that business, and I think that the responsibility of the field operations was gradually shifted onto the shoulders of Charles Clason.

George T. Hoisington

GEORGE T. HOISINGTON,

a witness for plaintiff, testified as follows, by deposition:

DIRECT EXAMINATION

My business address is 1212 Union National Bank Building, Wichita, Kansas, and I am district superintendent for The Halliburton Oil Well Cementing Company. I supervise all of the work this company does in my particular district, that is, cementing, acidizing, well logging, formation testing, dump bailer service, sales, flooding and accessory equipment used in and pertaining to all of the above services.

I have been with The Halliburton Oil Well Cementing Company since April, 1924, and have been working on acidizing since about January, 1935. The Halliburton Oil Well Cementing Company first offered a service of acidizing wells sometime, I would say, in the last half of 1934. As far as I know, this service was first offered commercially, on a revenue producing basis, in my district, that was in January, 1935. It may have been before that, but I do not know whether we had any revenue producing jobs before that or not.

My first acidizing job was run for either the Olson Oil Company or The Empire Oil and Refining Company. I do not recall which. I was treating wells for the oil producing companies, and at that time was in charge of The Halliburton Oil Well Cementing Company's acidizing service in Kansas.

If the period when The Halliburton Oil Well Cementing Company first offered acidizing services on a commercial basis dates from the delivery of the equipment specifically designed to do that work, then I was in charge of that service when it was first offered and that was in my district. At the time this service was first offered, it consisted of offering to deliver the hydrochloric acid and

George T. Hoisington

the equipment to put it in the well. We offered a treater, a helper, the equipment and the amount of acid requested by the customer. On the first two or three jobs, we used just straight fifteen per cent hydrochloric acid, with Mr. McPherson's surface tension reducer, as he referred to it at that time. At that time, I used no inhibited acid. During the time that I was in charge in Kansas I used inhibited acid after, I think, the second or third job which was about January and February 1935. The inhibitors used, as I recall, were Nep 22 and Murodine. I believe I purchased the Murodine from Thompson-Hayward Chemical Company, and the other came on request from Duncan, Oklahoma.

We would use the indicated amount of inhibitor that would be required by the volume of acid that we were running. You have a certain proportion of inhibitor in the amount of acid run. In other words, you use twice as much inhibitor in two thousand gallons of acid as you use in one thousand gallons of acid. I do not recall the indicated amount of inhibitor. The inhibitor was mixed with the acid at the time it was loaded out from the storage station.

We used these inhibitors up until the Circuit Court of Appeals handed down the decision in Denver, in the case of The Dow Chemical Company vs. Williams Brothers Well Treating Corporation, which was about 1936. I used the inhibitors, Nep and Murodine, in my district in Kansas from early in 1935 up to 1936, and those are the only inhibitors I recall using during that period.

By Mr. Conner:

Q. Mr. Hoisington, I show you here PX-19, 20 and 21 which purport to be treatments of wells made by the defendant company, and ask you to examine them and tell me if you have ever seen them before. A. I checked all the signatures of each of these. In the treatment of the wells reported in these reports, fifteen per cent hydrochloric acid was employed. I personally did not have anything to do with the treatment of these wells. I recall doing the initial solicitation and discussion and had most of the conversa-

George T. Hoisington

tions with Mr. Hilligoss. These wells were treated in the state of Kansas, which was my district. It was inhibited acid. The inhibitor was either Nep 22 or Murodine. We used an inhibitor on all treatments, and didn't think anything of it, up until the Circuit Court of Appeals' decision was handed down in Denver. There were one or two jobs run, possibly three, in which no inhibitor was used because we did not have it on hand and the customer did not think it was necessary.

Q. Mr. Hoisington, I again show you PX-19, 20 and 21, and ask you to state whether or not an inhibitor was used in those treatments to your knowledge. A. I rather think that it was.

Q. What is your knowledge of the situation as to whether an inhibitor was used in those wells or not? A. It was our policy to use an inhibitor.

Q. And that was your practice at that time? A. At that time, yes, sir. When we would take a thousand gallons of acid out to a location to treat a well with, we used an inhibitor and our surface tension reducer. That constituted an acid treatment when the job was completed.

Prior to the treatments recorded in PX-19, 20 and 21, the earliest of which treatments is dated March 2, 1935, The Halliburton Oil Well Cementing Company to my knowledge on one or two occasions made treatments with uninhibited hydrochloric acid when we did not have any inhibitor. I am quite sure it (inhibitor) was not used on the first job we run.

JOE KINNARD VERSER,

a witness for plaintiff, testified as follows, by deposition:

DIRECT EXAMINATION

I live in Wichita Falls, Texas, and have been employed by the Halliburton Oil Well Cementing Company since September 4, 1923. I have worked for the Halliburton Oil Well Cementing Company in their acidizing department.

By Mr. Owen:

Q. I show you PX-19, 20 and 21, and will ask you to examine them and state whether or not you had anything to do with the acidization of those wells? A. This Hilligoss well, yes, sir, I treated this well.

The Witness: I also treated this Oko Oil and Gas Company well (referring to PX-21). My name is signed to some of the papers on each of the three exhibits. The Hilligoss well was treated first. It was treated March 11, 1935; we used a thousand gallons of acid of fifteen per cent solution. I did not place any inhibitor in the acid used in this well. I do not think we placed any inhibitor in the acid on either of these other two treatments. At that time we were not using an inhibitor. I am sure we were not. I know we did not on this one (indicating PX-19). I do not know where we bought the acid. It was shipped in a car and I unloaded the car. I do not believe it was Dowell acid.

In this next treatment (indicating PX-20) we used a thousand gallons of fifteen per cent uninhibited acid. We used the same type of acid for quite a while. We were using the penetrant in raw acid. I do not know where the acid came from. It came to us in a tank car. I examined the tank car and it had a rubber lining. I remember that the tank car in which the first shipment of acid was received was also lined with rubber.

In the third treatment (PX-21) we used the same kind of acid, that is fifteen per cent uninhibited hydrochloric

Joe Kinnard Verser

acid with McPherson's penetrant. I believe all the acid for both of these tickets (PX-20 and 21) came in the same car, I am pretty sure, because they were run right along the same time, because we had only one tank.

I recall what inhibitor was used at a later date. The first inhibitor we used was Nep 22, that is a trade name; I do not know what the chemical is or its composition. I do not know where we bought it. Mr. Hoisington attended to that, he bought it through Duncan, Oklahoma, or bought it himself, I do not know. The next inhibitor we used was Murodine, but I do not know where we bought it. I do not know how long we continued to use one or the other of these inhibitors, because I stayed in the acid department only until about June or July of 1935 and then transferred to the cementing department.

CHARLES E. CLASON,

a witness called by plaintiff, testified as follows:

DIRECT EXAMINATION

I have been employed in the Duncan main office of the Halliburton Oil Well Cementing Company since May 20, 1935. My title has at all times been Superintendent of Acidizing. When I entered the employ of the defendant company it was already engaged in the business of acidizing oil wells. I don't know that they had any orders for

Charles E. Clason

acidizing on hand at that time. I think they had a job the day after, although I was not there. It was up in Kansas, and I was in Duncan. They had in stock acidizing materials at that time. They had muriatic acid or hydrochloric, in a storage tank, and that so-called reducer, and I believe they had some of that Nep compound inhibitor. I don't remember, but it seems to me they had some there in their pump house, at Hutchinson, Kansas. After I went with them they used that as an inhibitor for a time, and then Murodine. They used Nep possibly two months after I went with them and then they switched to Murodine. From hearsay, they used Nep as an inhibitor before I entered their employ. They stated that they had some on hand there. It was carried in stock at that time. I think I saw a drum there that had some in. Probably 50 or 52 gallons, whatever the standard is. It was a liquid. We continued to use what they had on hand, and did not buy any more. We then started using Murodine because it was easier to obtain, as we got it right in Wichita, Kansas, from Thomas and Hayward.

Before I went to work for the defendant, I worked for the Dow Chemical Company twenty years in Midland, and then I think it was about the time I went to Kansas that they organized the subsidiary unit of Dowell, Incorporated. That was in November, 1932. Regarding my duties with the Dow Company immediately prior to the organization of Dowell Incorporated, I was in the acidizing work here in Midland County. I was one of the first to get into that work with the Dow Company. I witnessed some of the early treatments of wells using the Grebe-Sanford acidizing method in Michigan, before I went to Kansas.

When I went to Kansas, I was in charge of Dowell's treating station, and continued in charge of that station for about two and one-half years, roughly. I left the employ of the Dowell Company about May 12th or 14th, along in there some time, 1935, and entered the employ of the defendant on May 20, 1935.

I am familiar with the construction of the steel tanks

Charles E. Clason

used by defendant for transporting acid to the wells to be acidized. The sketch which was made by Mr. J. J. Edwards during the taking of depositions in June, 1939, in this case, looks about the way they would if you looked down inside the top. In the upper figure marked Figure 1 the eight squares marked with an X, are lead plates and they are brazed or soldered to the bottom of the tank. I believe the custom is before those plates, which I think are about 30" square, are put into the tank, they weld a strip of steel or take a strip of steel and braze the edges of these plates to that strip of steel. Now, that is rather a fussy job, attaching that lead to the iron, lead burning, there are a lot of fumes concerned. That can be done in the open. Then when they come to here (indicating) it is a simple matter to spot weld the steel to the steel. The lead plates are put in at the Halliburton shops. We buy steel tanks and then equip them with these lead plates. This line marked A-A' shows the dividing line between the two compartments of the tank, which are not connected so that the acid can go from one to the other. One can be filled and the other empty. These other cross lines between the lead plates probably represent baffle plates. From the bottom they come up eighteen inches, I should say. Possibly a little more. They are to prevent undue slopping of the acid in transportation.

I know something about the electrical treatments that are given to these tanks before they are put into service. We found that when a new tank was put into operation there is a certain amount of current flow until the tank becomes polarized. Now, this current flow results in a deposition, I think, possibly, of lead. At least, it looks like it. I have never analyzed it. But, at least, there is some action there and the tank becomes polarized. Now, that is at the expense of the plates in the tank, and the action comes at the point of contact of the lead and steel. Well, now, naturally, a bare new tank, there is going to be a lot of action there at the start when the acid is put in, when polarization takes place. Now, to alleviate the using

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up, you might say, of those lead plates to the extent of where it loosens them, we hung some lead strips in the acid and connected a battery with it to actually deposit this, and thereby not have a job in a very short time of replacing those lead plates. We found that then they would last for a great length of time.

Mr. Lyon: What did you do with the acid that you employed in that polarizing operation? A. That was usually—it may be used, and it might—may have done two things. They have used that acid when it was strong acid, but they have had instructions that it isn't necessary. You could use a weak solution, two or three per cent, and throw it away.

By Mr. Owen:

Q. You mean they have used that acid, used in the polarizing operation, for treating wells? A. That particular tank load could have gone in a well.

In the polarizing operation, we drop down in the man-hole of the tank a lead plate which we connect up to the plus side of a battery. The direction of the current flow is from the lead into the acid to the steel and back to the other pole of the battery. The other pole of the battery we connect to the steel tank, as illustrated in figure 2 of this sheet, Mr. Edwards' sketch. I have seen them use for this purpose an ordinary 80 ampere battery such as used to go in Fords. They would let it run down completely. You could see it taking some lead off the lead strip, and that lead goes onto the sides of the steel tank inside. We do that preliminary treatment to prevent too much attack on the lead strips, which were previously placed in the tank. That action comes on the point of contact there.

Mr. Owen: I will offer a photostat of this pencil sketch which was made by Mr. Edwards as PX-71.

(The sketch referred to was thereupon marked PX-71.)

The Hailiburton Company stopped acidizing wells shortly after the decision of the Circuit Court of Appeals in the Williams case. That was perhaps in January of 1936. At that time I knew of the Chemical Process Company.

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They were in the business previous to that time. I did not know what kind of acid they were using. Previous to that time, January, 1936, I think pretty near everyone used inhibited acid.

Mr. Lyon: Are you testifying you had any knowledge? A. No, that is just an opinion. I don't know.

PX-186, which is entitled Howco Method of Protecting Tubing and Casing against corrosion while acidizing a well, and which bears the date March, 1937, on the title page, was published quite a little time after defendant started acidizing again. I think this was the first published announcement, but I think they had actually started in business before this was published. I think it was in June, 1936, they started using that Menaul method.

During that period from January to June the Halliburton Oil Well Cementing Company was out of this acidizing business entirely, for this purpose.

CARL A. NICHOLAS,

a witness called by plaintiff testified as follows, by deposition:

DIRECT EXAMINATION

I am 31 years old and employed by the Halliburton Oil Well Cementing Company as a treater. I supervise acid treatments of wells made by that company, and, at present, am located in the Salem oil field in Illinois where I have

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been since about the first day of May, 1939. I have been employed by Halliburton since December of 1936.

From April 20, 1938, until February, 1939, I was stationed at Mt. Pleasant, Michigan and worked for the Halliburton Oil Well Cementing Company in the capacity of a treating engineer in charge of acidizing oil wells. My job was that of supervising the acid treatments given to oil wells by Halliburton, and I checked the field and also solicited business. The Halliburton Oil Well Cementing Company, at Mt. Pleasant, Isabella County, Michigan, maintains an office with a telephone listing and a treating station from whence they acidize oil wells.

At the time I was located at Mt. Pleasant, Halliburton had two combination units, which handled both acid and cementing, and equipment for transporting acid to the wells. At Mt. Pleasant, Michigan, Halliburton also had two acid storage tanks which were located just back of the Sun Oil Company's bulk plant, right across from the Isabella County Railway yards on the north side of town. These storage tanks were made of wood and had a capacity of 250 barrels each.

As to the various services and materials which Halliburton offers to the petroleum industry in connection with acidizing oil wells, I am familiar only with those services and materials that I used. I am familiar with the type of acid used by Halliburton and know that hydrochloric acid of 15 per cent is used when acidizing oil wells. I obtained all of my experience as an acid treating engineer after having come to work for the Halliburton Oil Well Cementing Company.

I am considered to be an experienced treater and am sent out to a well and given full charge of treating that well. As a rule, I do not have any assistance in treating a well other than truck drivers who drive the trucks to the well location and do the necessary work of hooking up various pipes and pumping the acid into the well. I supervise the job.

When I was located at the Mt. Pleasant Station of the

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Halliburton Oil Well Cementing Company, I had occasion to treat wells in Ogemaw, Arenac and Gladwin Counties, Michigan. When treating wells in these counties the acid employed would come from Halliburton's station at Mt. Pleasant, Michigan. To my knowledge, I never treated any wells in these counties wherein the acid did not come from Halliburton's storage at Mt. Pleasant, Michigan. In treating an oil well, as a rule, I would be present when the transport tanks were loaded with acid from the storage tanks. In treating a well the first thing we would do would be to get our truck drivers together and then load the acid transport tanks with acid. Water was always first loaded into the acid transport tank, and then 20 per cent Baume acid was added to this tank from the storage tanks at Mt. Pleasant.

Then, of course, we had to make the trip to the well location and after that, the first step in treating the well would be to load the well hole with oil. Then, you would proceed with your acid treatment by putting your acid into the well. The usual procedure is to bleed off oil until you have your formation covered with acid and then you close in the well and force the acid into the formation. The tubing and open well hole is flushed with oil so that all of the acid is forced into the formation. Pressure is used in order to force the acid back into the formation. When we arrive at a well to treat it, we would have a truck with a pump mounted on it, and the truck would be pulling a trailer containing an acid transport tank.

The truck driver or drivers and myself make all necessary pipe connections to place the blanket, acid and oil in the well hole. Employees of Halliburton make these connections, and operate the pump to put the blanket, oil and acid into the well. All operations relative to treating a well with acid are done by Halliburton employees, and when anyone other than myself does any work in connection with treating a well, that work is done under my instructions and supervision.

Part of the hydrochloric acid used by the Halliburton

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Oil Well Cementing Company in treating oil wells in Michigan came from the Pennsylvania Salt Manufacturing Company at Wyandotte, Michigan, and the rest of the acid came from the General Chemical Company at Norwich, a suburb of Chicago, Illinois. The acid was shipped to us in rubber-lined tank cars. Part of the time I unloaded the acid from the tank cars and put it into the Halliburton storage tanks and part of the time some of the other employees of the company performed this operation. I checked the unloading of this acid, and when a tank car of acid was received I was responsible to Mr. Edwards for its unloading. As a rule, when a tank car of acid was received at Mt. Pleasant it was unloaded that same day, and put into the storage tanks. That was our usual practice. When we used this acid to treat wells, it was diluted with water.

The formations from which the oil wells in Michigan produce oil are limestone and dolomite. I know the action that hydrochloric acid will have on calcium carbonate and on typical limestone formation. The action is such that the acid will consume a certain percentage of the calcium carbonate, and that is the reason we used hydrochloric acid in treating these limestone formations in Michigan. By pumping the acid into the formation under pressure you merely open channels in the limestone which are formed by the acid spending itself on the formation. Whether or not it is necessary to allow the acid to remain in the formation any length of time depends entirely upon the formation. Some formations are fast reacting when subject to the acid and some react slowly. The length of time that the acid is allowed to remain in the formation sometimes varies from an hour to several hours.

When I received the acid from the manufacturer, I made no tests or analyses of it. When I took it out of the storage tank prior to putting it into the transport, no tests or analyses of the acid were made at that time, nor were any tests or analyses made at the time it was put into the transport tank and before it was put into the well. When the acid was taken out of the storage tank and prior to

putting it into the acid transport tank or after it was put into the transport tank but before putting it into the well, I usually tested the acid with a hydrometer to check it to see if it was 15 per cent strength treating acid. The only tests I made at any time between the time I received it from the manufacturers and the time it was used in acid treating a well was merely a test made with a hydrometer to determine the strength of the acid. With respect to the materials employed in treating wells in the counties of Ogemaw, Gladwin and Arenac, Michigan, no tests were made of these materials just prior to putting them into the well. I did not save any samples of these materials. There were some instances where the operator saved samples of the acid. What he did with them I do not know. I made no tests or analyses of the acid while it was being retained in the storage tank at Mt. Pleasant, Michigan. To my knowledge, no samples of that storage acid were retained and I never retained any specimens of that acid and saved them. It has never been my practice to make such tests and to take such samples while the acid was being retained in the storage tanks at Mt. Pleasant, Michigan, and I never saw or heard of anyone doing it.

I am familiar with and know the construction of the equipment employed by the Halliburton Oil Well Cementing Company in acidizing wells. The acid transport tank is a steel tank and is built on a trailer. Those used in Michigan are constructed with two compartments of 500 gallons each and have baffle plates crosswise and lengthwise in each compartment. These tanks have lead plates bonded in them, and there is a dome in the tank for filling it. The tank has a suction manifold with two connections, one leading to each of the two interior compartments. I believe there are four lead plates bonded to the bottom of each interior compartment of these transport tanks. I do not know the exact size of these plates. I believe they are about 30 inches square, and that there are eight in all in each transport tank. These plates are about one-eighth inch in thickness.

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When treating an oil well with acid, aside from the pipe connections that extend from the pump or acid tank to the well tubing, there is another connection which comprises a heavy electrical bronze cable, one end of which is connected to the acid transport tank and the other end to the well tubing or casing.

I have acid treated better than 100 wells in Michigan and they were all treated by me while working for the Halliburton Oil Well Cementing Company. When we first went in the acidizing business at Mt. Pleasant, Michigan, the original acid transport tanks were there before I arrived. Some Ford transports arrived at Mt. Pleasant after I was there and they had tanks on them for transporting acid.

Before utilizing these tanks for transporting acid, they were electrically polarized and there was one or two of these tanks that came to Mt. Pleasant, Michigan, that had not been electrically polarized. These tanks were polarized by using 15 per cent acid and extending lead strips down into the acid. These lead strips I refer to are additional to the eight lead strips which are bonded to the bottom of the tank compartments. The additional lead strips are put on a wooden frame that sets across the dome of the tank, and they are connected to the tank through a storage battery which is then allowed to lose its charge in that process. Now, as to what happens there, I would not be able to tell you. I merely followed instructions as to what was to be done. I helped position these additional lead strips in the tank. Only a portion of these additional lead strips was immersed in the acid, but they were not in contact with the walls or top side of the tank, but in contact with them only through the battery. By means of wires, I helped to make the connections connecting the battery up with these additional lead strips on the inside of the tank. I saw this done. We used an ordinary six-volt storage battery.

When I would treat or supervise the treatment of wells in the counties of Ogemaw, Arenac or Gladwin, Michigan, I would make a record and report of that treatment to the Halliburton office in Mt. Pleasant, which consisted of a

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data sheet, in the form of a work order. This was always made out before the acidizing job was done and was signed by the operator or the well owner's representative. We kept an acidizing ticket as a record of the well treatment. The acidizing ticket showed the time involved in making the treatment and the pressures required or actually used in forcing the acid into the formation. The acid ticket further would show that the well was treated by the Halliburton Oil Well Cementing Company, would give the date of the treatment, the address of the party or well owner for whom the treatment was made, the position or location of the well as to the lease, well name, section, township, range, state, county and pool, where such information was available. The acidizing ticket also gave the time that our equipment arrived at the well, together with the numbers of the equipment to identify it, the distance of the well from the station making the treatment, the amount of oil used in treating the well, the number of pumps used in placing the acid, oil and blanket or other material used into the well, and also indicated on this ticket was the time when the acid was placed in the bottom of the well.

The table entitled "Pressure Record" appearing on the acidizing ticket is for the insertion of figures in the time column to show the length of the treatment. This column will indicate any changes made in the treatment with respect to the volume of fluid and the pressure required to force it into the well. Any time there is a change in the pressure or change in the directions of treatment in any way, that is recorded on this record. Under the headings "Time," "Vol. acid in," "Casing" and "Tubing" (the last two headings under "Pressure") at any given time show the amount of acid in the well at that time. The next column to the right shows the pressure on the casing and on the tubing, together with the amount of acid in the well. The acidizing ticket further shows the amount of oil used to flush the well and the pressure on the casing and on the tubing at the end of the treatment; and the ticket further shows the materials used and the charges made therefor by the Halliburton Oil Well Cementing Company,

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At the bottom of the acidizing ticket appears the word "treater," at which place the Halliburton treating engineer would, as a rule, in his handwriting, insert the name or names of the Halliburton men helping him. Over the line marked "Owner of well or agents" the well owner or his agent signs his name. The acidizing ticket is further filled out to designate which of the Halliburton treating stations is rendering this acid service. The well owner or his agent is given a copy of this acidizing ticket. It was my practice while employed by the Halliburton Oil Well Cementing Company at Mt. Pleasant, Michigan, and when making acid treatments to fill out such a record as I have been discussing, which record is entitled "Acidizing Ticket."

I have examined the acidizing ticket No. 6581 of the Halliburton Oil Well Cementing Company, and this ticket is a report on a well which I treated. The well was treated for the Chapman Oil Company, April 27, 1938, using a thousand gallons of penetrating acid and 4 gallons of blanket. The well treated was the State Well No. 2 located in Midland County, Michigan. I was the treating engineer in charge of acidizing this well, and this well was treated for profit. I have also examined acidizing ticket No. 6583 of the Halliburton Oil Well Cementing Company, and this record indicates that bean powder and blanket were used in treating the well listed in this report. I have also examined the acidizing tickets Nos. 8184, 8185, 8188 and 8196 of the Halliburton Oil Well Cementing Company.

Mr. Owen: Your Honor, these last tickets are the treatments that are involved concerning which infringement is charged.

Mr. Lyon: I didn't quite understand the statement of Mr. Owen. What is there in particular about these four tickets?

Mr. Owen: These are the tickets which relate to the treatments from which the samples were taken upon which the charges of infringement are based.

Mr. Lyon: We are going to object to any evidence in regard to those treatments, the samples, if they are relied

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upon to establish infringement because their position is—I don't think it is contested—that those wells were acidized and the treatment performed with the consent of the plaintiff. Of course at the plaintiff's instigation, and the plaintiff cannot sue, and Halliburton is not liable as an infringer for carrying out Weber's request, or what Weber had been authorized to do by the Dow Company. We object to the evidence of those wells. I don't think you deny that the Dow Company authorized the Weber Company to hire Halliburton. We object to that. I don't think you deny that the Dow Company authorized the Weber Company to hire Halliburton to perform those treatments.

Mr. Owen: I am perfectly willing to state to the court just what took place. Plaintiff had for some time endeavored to secure evidence of just what the defendant was doing, just what it was using. The manner and nature of this business is such that they had no means of ascertaining when the Halliburton Company was to make a treatment. They couldn't get that information from the Halliburton Company. They had no means of knowing when or where Halliburton was to make a treatment, and therefore, in order to secure samples of the materials that were being used by Halliburton, the representative of The Dow Chemical Company, or of Dowell, I don't know which, arranged with the Weber Oil Company to secure a certain number of treatments from the Halliburton Oil Well Cementing Company and to take samples of the materials used which were to be delivered to plaintiff, and that was done.

The Court. Who paid for the job?

Mr. Owen: So far as the transaction between Halliburton and the Weber Oil Company was concerned, the Weber Oil Company paid for it, although the Dow Company reimbursed the Weber Oil Company but Halliburton didn't know that.

Mr. Lyon: How do you consider that an infringement?

The Court: The plaintiff gets something that is infringed in the trade, and goes around and buys things, I suppose, to catch the claimed infringing defendant, and I

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have never had that question raised before. I suppose they could say in all those cases, a bolt or nut claimed to be infringement made by the defendant, and they get some retail fellow out in the country somewhere to order it.

Mr. Conner: If Your Honor please, at this time it seems that defendant finds itself in this position, that here they are in Mt. Pleasant, they have a place of business, they are acidizing wells, they are accepting such business, they are trying to get this business. Now, merely because they treat wells for these particular people, they maintain under that circumstance,—and we get evidence of what they are doing, that that is not infringement; but, you must not fail to see that they are taking all the acidizing business they can get, and doing the same thing on each and every well.

This thing of treating a well is a very hard thing, usually. I don't know how much business they get, but in order to get evidence of the infringement,—it is not a material thing, it is not solid, it is a method claim, and in order to get evidence whether they are infringing or not we have to be right there and watch every single step they take, and how they do it, and what they do it with.

We arrange for these treatments. We ask Weber, will you get some treatments from Halliburton. Does Halliburton have to take those treatments or not? All they do is accept that business in their normal course of their everyday operations.

The Court: I was trying to say, but I was interrupted, it is just the usual thing that I get in all cases. This is the first time I have ever had this question raised as to whether most of them prove the infringement. If there is any difficulty at all they get some people that are engaged in business out around that are friendly to the plaintiff, the patent owner, to order some of these things. I don't suppose when we come to an accounting, perhaps, that they include that at all. I don't know. But, they do the same thing in criminal cases.

Mr. Conner: I want to get in here there is no such

thing here as entrapment. There is no question of entrapment.

The Court: They don't claim entrapment. We are right in this building. We will say this building and every other post-office building is built with peek-holes so that they can watch the clerks, and the clerks all know it, but in spite of that once in a while they are so tempted by a letter they see money in, they take it. They haven't the right to send those things through the mail, put temptation in their way; they haven't a right to go and coax somebody that isn't violating the law to become a violator. Then you get over into the inducement, and I never liked the word, because I always understood you always had the right of setting a trap, and they do it in criminal law. They set a trap. And, they fall through it if they are regularly in the business. They do it with bootleggers. You could go to a man who is making moonshine and coax him to go and make you some, and offer him good money, and he goes. The officers of the law do that. That is putting temptation in the way of an honest man.

But if he already is doing the thing, and you just try to get proof of what he is regularly doing, then I understand you have a right to do it. You didn't do this different because they did not specifically ask you, as I understand it, to put certain things into it and do it in a particular way.

Mr. Lyon: Well, they asked us to put the blanket in.

The Court: What?

Mr. Lyon: They asked that the blanket be put in for one thing. I haven't finished my explanation of my point, if you please, if I could.

In the first place, there is a principle that jurisdiction in the Federal Court cannot be established by collusion, and in this case the Halliburton Company is not an inhabitant of the State of Michigan or of this District. In order to establish venue in this case, the defendant, as I understand it, relies upon these particular four wells—or the plaintiff does. And, to prove infringement, Halliburton Company

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not being an inhabitant of this district, it can only be sued if it has a principal place of business here, which it has, and has infringed here.

The Court: Yes.

Mr. Lyon: Now, then, to prove that infringement, which is denied in the answer, the plaintiff relies on the collusive transaction here between this Weber Oil Company and the other oil company, the Petroleum Investors, Incorporated. And they say, "Here, Halliburton, you have infringed because you have treated these wells for these companies."

Now, that couldn't have been an infringement unless the Petroleum Investors Company and the Weber Company were infringers. The work orders which are here in evidence under which this work was done provide as follows, typed on each one:

"Also it is necessary in work of this nature to depend largely on indicated conditions in a well and there being natural uncertainty as to measurements and variations of formations to be treated it is expressly agreed—" these were signed by these oil companies and Halliburton—"—first, that Halliburton Oil Well Cementing Company makes no guarantee of the effectiveness of the materials to be used in the treatment of the well nor of the results of the treatment.

"B. That it shall not be liable for any injury or damage to the well growing out of or resulting from the treatment of said well or from the use of said equipment in doing said work.

"C. Halliburton Oil Well Cementing Company only agrees to furnish the materials here on order and any equipment suitable for placing said materials in said well and two operatives to assist in performing the work under the supervision of the owner of the well or his representative."

So, unless the owner of the well, the man for whom the work was done, was an infringer, Halliburton can't be a contributory infringer or joint infringer. You can't be a

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contributory infringer unless you contributed something to such infringement, or you can't be a joint infringer unless there was another joint infringer, and in this case these oil well companies were authorized by the Dow Company to do this very job. They had their permission.

This isn't a question of entrapment. We are coming down to the question of whether or not this is a legal venue of these four cases, if they can be used to establish venue here, because they were by collusion. And if Your Honor hasn't read it I would suggest you consider the decision of Judge Westenhaver in *Southern Textile Machinery Company vs. Wovenright Knitting Company*, 44 Federal Second 234, a decision he wrote in 1925 under this venue statute in patent cases, dismissing the case because there was collusion in establishing the venue. The plaintiff went in there and colluded with the person to establish the sale in that district.

The Court: How about this line of reasoning, though: The proof already shows that they probably have treated 100 wells in this jurisdiction here. Now, then, they analyze only four wells, and your objection, if you are limiting it to that question of collusion—but how about taking that as very good circumstantial evidence of the fact that all of those wells that you have been treating here were of that kind?

Mr. Lyon: Well, my objection is based on this, Your Honor, because I asked Mr. Owen what he relied on those four wells for, and he said those were the four he was relying on to establish infringement.

The Court: But I realize that he relies on those four, and then I don't know whether he does or not, but I would assume that circumstantial evidence as to the others—in other words, suppose I found against you all the way through and you finally got around to the accounting, the court wouldn't stop with an accounting as to only those wells they analyzed, but they would use that as circumstantial evidence of what was done in the other cases, I think.

Why not use that in the same way as to this? I don't

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see as they are limited to the four wells they have analyzed. That is all they have analyzed and from that they draw certain conclusions. You take—oh, I don't know whether I can think of a good example or not, but we have it all the while. We go into—well, take the ordinary bootlegging case, you go in and they see them selling drinks right along, they watch them for a while, and they are selling drinks. They go in and they buy only one drink, but you reach the conclusion that they are bootlegging to the others because of what the one got. He will ask for the same thing, the same thing he hears them ask for.

Mr. Lyon: I see Your Honor's point all right, but I don't see what it is going to lead us to, because the proofs so far as they have disclosed in the preliminary depositions in this case, I can't tell whether they charge that on these four wells something was added to these acids, some minerals were put in the acid or some inhibitor put in. They present certain analyses of the acid before and after. Now, we asked them if they wanted to stipulate if what was done on those four wells was typical and representative of what was done on the other wells they were treating in Michigan, and they refused to stipulate.

Mr. Owen: No, we didn't have any such proposition, and I am perfectly willing to stipulate to that.

The Court: They certainly can't get any stronger conclusion unless they prove something.

Mr. Lyon: If they are going to contend that on those four wells somebody put something in the acid, which we say we did not do, and those jobs were done at their request, the evidence shows, for instance, that in connection with the well for the Petroleum Investors, one of the four they rely on, that as a matter of fact the Dow Company had a man there in the field who told them what they wanted done, and directed the treatment of the well as to the putting in of the blanket, and so forth, and the Halliburton people thought he was a representative of the Petroleum Investors, but he was a Dow man.

If they are going to rely on any finding of iron or

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copper or anything else in these acids, we are not willing to stipulate, and I don't think the court should infer from that that there would be such things in the other wells, as they say that that proves that somebody put something, some copper or some lead or something into the acid.

If they are willing to take our statement that no such thing was done, why then, of course, we are not so much concerned about this point, but what we are concerned about at this point is that if they are going to argue that something peculiar, something beyond what we admit we did here in these four wells occurred, they are going to rely on these four wells and their analyses on these four wells to establish their infringement, we want to reserve the point that those four wells are not infringing wells.

The Court: Well, I will overrule the objection, and you have got your exception to it, and whether I have got circumstantial evidence that leads to some certain conclusion or not, I will have to wait until I have heard all of the evidence and all of the circumstances and every other kind of evidence. But I think that fully protects your record and I will let them go ahead. I will overrule the objection.

Mr. Owen: I would like to state this for the record, Your Honor, that the plaintiff is relying upon what we found in the acids from these wells, and what the defendant did in treating those wells, as representative of the treatments that they were giving throughout this district, and that if the acids of which we took samples, and those particular treatments, are infringements, we will contend that all of the other treatments made during the same period, by the defendant company, in this district, were also infringements.

The Court: I will hear the proofs. They probably will be telling me about what was done there, and how it was done, and what was done in other places, before they are through. Anyway, I will hear the testimony.

You may go ahead.

The Witness: I have examined the acidizing tickets

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Nos. 6581, 6583, 6585, 6587, 6589, 6592, 6594, 8161, 8167, 8176, 8184, 8185, 8188, 8196 of the Halliburton Oil Well Cementing Company, and these tickets are reports on wells which I acidized or which were acidized under my direction, as a representative of the Halliburton Oil Well Cementing Company. I was the treater in charge of acid treating all of these wells referred to in the above tickets. These wells were treated in the State of Michigan from the Halliburton Oil Well Cementing Company's Mt. Pleasant station. The wells which were treated and reported in the acidizing tickets Nos. 8184, 8185, 8188, and 8196 were treated by the Halliburton for the Weber Oil Company. These wells were located in Ogemaw County, Michigan. There is data on these tickets which indicates whether or not we employed pressure in connection with placing the acid in the well. The pressure indicated on these tickets shows the pressure it took to pump the acid into the formation. I put the acid back into the formation, or rather, I endeavored to put it back into the formation. So far as I know, the data on these tickets truly represents all of the facts relative to the actual treatment of the well. These tickets also give the location of the well and the materials employed in treating it. The acid was forced into the well by the application of pressure and the well was closed in so that the acid could not come out of the well. I do not remember exactly how long the acid was allowed to remain in the well, but it stayed there a few hours possibly. The acidizing tickets do not indicate how long the acid stayed in the well.

Acidizing ticket No. 8188 shows that a two-stage acid treatment was given to this well and that after the first stage was finished the acid was allowed to stay in the well for a short time. I would not attempt to say how long the acid stayed in the well, and the acidizing ticket does not indicate this. As indicated on the acid ticket No. 8188 between the time of 11:38 a. m. and 2:30 p. m. the acid was allowed to stand in the well a while, and then the well was swabbed and cleaned up. The second stage of the treat-

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ment then proceeded, commencing at 2:30. After the second stage of the treatment, the acid was allowed to stand in the well for a while, but how long I could not say. This was done under the supervision of the superintendent of the Weber Oil Company and he took care of that himself. He told them how long to leave it set and how long to swab it. This acidizing ticket No. 8188 reports on a three-stage treatment.

I have examined acidizing ticket No. 8184 of the Halliburton Oil Well Cementing Company and, to my knowledge, this ticket is a report on the first well acidized by Halliburton for the Weber Oil Company. At the bottom of the ticket appears the name W. L. Steelman, whom I contacted with respect to this well, but I do not know exactly when. He was in charge of this Stella Wilcox well. I treated the Stella Wilcox well as indicated on these acidizing tickets on two different occasions, namely, on August 2 and on August 5 of 1938. I can not tell by reference to these tickets whether or not this well had been acidized before. I would have been told by the well operator, as part of my knowledge preparatory to treating the well, if the well had been previously treated. I cannot say whether that well was acidized by anyone else prior to August 2, 1938, when I acidized it for the first time.

When treating the Weber Oil Company's Wilcox well on August 5, I used 2000 gallons of acid and 25 barrels of oil to flush the acid and with which to push the acid back into the formation. When I finished treating this well, the acid was allowed to remain in the well for a short time. I do not know how long. To get the acid out of the well, the well was swabbed by the Weber Oil Company.

By Mr. Conner:

Q. At your completion of acidizing that well on August 5, could the satisfactory acidization of that well be effected without swabbing or withdrawal of that acid? A. What I can't understand is what you mean by that. It has got to come out.

Q. The acid must come out of the well in order to

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satisfactorily acidize that well, is that correct? A. Here is the thing, the well has to be produced. And in order to produce it, you are going to have to remove the fluid. When they go in there to produce a well, as far as whether the treatment is successful or not, the time that is left before it is put on production is probably immaterial as to the results of the treatment.

Q. You stated as far as you knew this well had never been acidized before? A. I could not say. I don't remember and I could not tell by looking at this ticket here.

Q. Then, as acidizing treating engineer, when you finished the acidization of that well, as reflected by that ticket, for the Stella Wilcox on August 5, what if any instructions did you give Mr. Steelman, as the operator, relative to putting that well back on production, with respect to the withdrawal of any spent acid or fluids in the well before the well could be produced again and production from that well put into the production lines or tanks? A. Well, to my knowledge I gave him no instructions, because I worked under his instructions on those jobs, and in this particular case there, Mr. Steelman told me what he wanted done, instead of me making any suggestions. However, had it been against the ethics of treating or anything, I probably would have made some suggestions, but in this particular case I gave him none that I know of.

Q. You testified that you have treated some 200 or more wells, is that correct, with acid? A. Yes, sir.

Q. Now, is it now necessary, after putting the acid into the well and forcing it back into the formation with oil, and after the well had been shut in for a period, to then remove the spent acid or fluids from the bottom of the well before the well is put back on production? A. In most cases, yes, sir.

Q. All right. When you were treating a well for an operator, who had never had a well treated before, did you not instruct the operator as to what should be done in order to put that well back on production? A. I merely gave him suggestions of what other operators have done. After

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all, either the operator or some representative of his usually has some knowledge of the acid business.

Q. Then, removal of the spent acid is a necessary step to the acidization of a well, is it not? A. Surely.

Q. This spent acid must be removed, is that correct? A. In lots of cases you don't get your spent acid back.

Q. But if it is there and can be gotten back, it must be removed before the well is producing again, is that correct? A. Some wells are put right on production without removing this spent acid.

So far as I know, the acidizing tickets that I have referred to are the most complete records relating to the treatments of the wells reported in these tickets, I made all of the entries recorded in these tickets and, to my knowledge, they are true. I did not retain any specimens or samples of the materials employed in treating the wells recorded in the acid tickets Nos. 8184, 8185, 8188 and 8196. I do not know whether anyone else in my organization retained any specimens or samples of the materials used in treating these wells. I made no tests or analyses of any of the materials employed in treating the wells identified by these four tickets, and I do not know whether anyone else in my organization made any tests or analyses of these materials. I did not make any tests or analyses, and so far as I know, none of the other employees of Halliburton made any tests and analyses of the particular materials used in treating these four wells.

Neither I nor anyone else in my organization, to my knowledge, made any tests or analyses of the materials used in treating the wells referred to in the other acidizing tickets, and neither I nor anyone else in my organization, to my knowledge, retained any samples or specimens of the materials employed in treating any of these other wells.

Q. Did I not understand you to state that after you and your crew had finished operations of putting the acid in the well, that you, in some instances and on some occasions, made suggestions to the operator relative to what should then be done with the well in order to put it back

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on production? A. There are some cases when the operator and his employees are not familiar, and I merely suggest policies followed by other companies and their employees.

Q. What are those suggestions you made on those cases? A. That would depend entirely upon the situation to be covered.

Q. What suggestions of any type have you made to the operators under those conditions? A. Well, that would be awfully hard to say. I could not go back and recall them.

Q. Can't you give an example of such a situation? Did you not tell him what should then be done with the well in the event he did not know of it, in the instance we are now speaking of? A. No, sir, I would not want him to use my word as authentic.

Q. Can you give us no examples of such suggestions as you stated you have made to operators in such cases? A. No, I could not, for the simple fact that most operators have their own ideas about that. I can't recall any instance, where I told them a set rule or gave them any instructions to follow.

Q. You do know, though, that in order to satisfactorily conclude the acidization of a well, that the spent acid, if it is there and be removable, must be removed, do you not know that to be a fact? A. Surely, it should be removed. I know that from practice.

Q. And you do know, as a matter of fact, that the spent acid is removed, be it removable from a well after it has been acidized, whether you acidize it or anyone else, is that correct? A. Here is the thing, a lot of wells are put on production and that acid water is removed right along with the production. They do not make any attempt to clear up that acid water before they put it on production.

Q. When spent acid is removed from a well, do you know what operations are performed to get it out of the well? A. It is usually swabbed.

Q. Will you explain how that acid is gotten out of

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the well by swabbing? By that, I mean how is the spent acid gotten out of the well by swabbing? A. After the operator determines the shut-in period, and after he leaves it shut the length of time that he had decided upon, I presume you know what a tubing swab is; well, they merely swab that tubing down until they have swabbed sufficient fluid to carry out the spent acid. In some cases they, of course—most cases, the spent acid is noticeable when it comes back, and after that spent acid has been swabbed back, they then proceed to put the well on production.

Q. Then you are familiar with the methods of removing spent acid after acidizing? A. Surely.

CROSS EXAMINATION

When I am treating a well for the Halliburton Oil Well Cementing Company, right after I have put the acid in, that is, after I have pumped the acid into the well, I then pump the flushing oil in the well right behind the acid. After that, I am finished with the treatment.

RE-DIRECT EXAMINATION

By Mr. Conner:

Q. You stated that after you have finished putting the oil in on top of the acid and place the acid, that you are then through with the acidization of that well, is that your statement? A. That is correct.

Q. What will keep the oil in the tubing and in the casing? Are there any closures made by way of valves? A. There is always a tubing gate on the tubing.

Q. Is that tubing gate closed? A. The tubing gate is closed until we have broken off our connections, then the operator, it is up to him whether he wants to go ahead, let that come back immediately, or whether he wants to let it remain in that well for some length of time. It is immaterial.

Q. Is there also a tubing gate on the casing—would

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it not be necessary to have the tubing gate on the casing closed to keep the acid and oil in place? A. That is right.

Q. Then, when you break your connections from the tank and tubing to leave, before you can do that, the tubing gate on the tubing must be closed first, must it not? A. Yes, sir.

Q. Now, it is necessary, is it not, to close that tubing gate and close the casing gate valve in order to keep the acid in position? A. That gate is merely closed after we finished treatment, for us to break away connections.

Q. I am not asking who closes it, but I ask you, is it not a fact that it is necessary to have the casing shut in and the tubing shut in after you have put that acid and oil in the well? It is necessary to have those two valves closed in order to keep the acid and oil in its proper place and effect acidization in the well? A. That is very true, but after the acid is pumped in there, there are some formations that it is complete the minute that acid is pumped in the formation. It is the general practice in lots of places that the operators remove that as soon as it is pumped in. There is no shut-in period.

Q. When there is a shut-in period, is it not then necessary to keep those valves, namely, on the tubing and casing, closed? A. That is right.

Q. When you are pumping oil into the well on top of the acid, there is this connection between your pump and the source of oil and the tubing, of some sort, is that not right? A. That is right.

Q. Now, you have put in sufficient oil, as you have computed it to be necessary, and you are to break your connections, go on home and eat dinner, who, as a matter of fact, unhooks your connection from the well? A. Usually my employees, those under my supervision, sometimes the employees of the operator.

Q. Then, who closes the valve on the tubing before the connection is broken? A. That is either one of the operator's employees or myself and crew.

Q. Then, in some instances it could be yourself or one

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of your helpers who does close the valve on top of the tubing? A. It is possible, but we are working under the instructions of that operator.

Q. You said, though, did you not, that sometimes you did that? A. That is right.

Q. Is that also true with the valve on the casing? A. It is.

Q. It is already closed, is it? A. It is already closed.

Q. In connection with the stage treatment, for instance, a two-stage treatment, is the acid left in the well any length of time, when the acid is put in in the first stage?

A. Well, that all depends upon the operator, whether he wants to let it stay or swab it right out.

Q. Assuming you are treating a well in two stages, and doing it all in one day, when the first batch of acid constituting the first stage is put in the well, do you withdraw that first batch? A. In some cases the operator does, in some cases he does not.

Q. In the cases where the operator does not withdraw it, who does withdraw it? A. It is usually the operator or one of his men there. On stage treatments, usually the first stage is considered, you know, kind of immaterial as to leaving it stand and it is usually swabbed right back out.

Q. Now does the operator know it should be swabbed back out if you don't tell him to? A. Well, now, that is the operator's business. Here is the thing, nearly every operator, especially any operator that has any production at all, has a man that he depends on for that purpose.

Q. Well, acidizing is your business, is it not? A. That is right.

Q. Isn't that two-stage acidization of the well one of the services you offer? A. That is right.

Q. One that you recommend under certain conditions? A. Well, of course we could recommend it, very true.

Q. You do give two-stage treatments? A. That is right.

Mr. Owen: Then we will put the large bunch, beginning with 6581 in as Exhibit 17, twelve tickets.

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And the four tickets which are not a part of the large bunch will be offered as Exhibit 18, four tickets.

(The tickets referred to were thereupon marked Plaintiff's Exhibits 17 and 18, respectively.)

The Court: That is right. And the objection goes to PX-18 and I overrule it and admit it.

PAUL G. SHELLEY,

a witness called by plaintiff, testified as follows by deposition:

DIRECT EXAMINATION

I live at Midland, Michigan, and have been in the employ of The Dow Chemical Company as a research chemist since October, 1936. My work has to do with oil production in general, but especially with acidizing development, developing techniques, and methods and solutions used in acidizing wells. The majority of it has been laboratory work, but I would say at least 25 per cent of it has been field work.

I am familiar with the methods of acidizing oil wells to increase production by using hydrochloric acid and I have observed acid treatments given to oil wells located in most of the Michigan oil fields, Greendale, Porter, Allegan, West Branch, over west of Grand Rapids, and also down in Clay

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County, Illinois, and in Louisiana. I have treated a dozen or two or more wells with acid to increase their production.

I have witnessed the Halliburton Oil Well Cementing Company acid treat wells owned by the Weber Oil Company, the Stella Wilcox Well No. 3 treated on August 5, 1938, the Robert Zahn Well No. 2 treated on August 19, 1938, and the Crawford Well No. 5 treated on September 10, 1938. These wells were located in Ogemaw County, Michigan, and were all given acid treatments by the Halliburton Oil Well Cementing Company. I was present and observed the treatment of all of these wells.

With respect to the Wilcox well which was treated on August 5, 1938, I went over to the well about seven o'clock in the morning. The driller, Stanley Hamilton, was there. We swabbed the well a few times. I found out at that time they had a packer set, a pipe which was about at the pay—about 2600 feet deep, I believe. About 8:30, I guess it was, the Halliburton men came to the well. The treater, Carl Nicholas, came in a coupe with the Halliburton name on it, then there was an acid truck and trailer, carrying 2000 gallons of acid, also a Halliburton piece of equipment that came at the same time, driven by a driver whose name I believe was Harold Aspin. Nicholas asked, as soon as he got there, to see if the well was swabbed dry; he checked the annular space, opened up the casing head, poured a little water in it, found it was full, plugged it up and made the connection. Then they made connections from this part of the pump to the tubing head, connected up the cable from the truck to the tubing head. The first thing they pumped about 10 gallons of some stuff that they called blanket into the tubing and then immediately followed that with acid, and continued to pump acid until they had pumped the entire 2000 gallons into the well. The first part of the acid, about 1500 gallons, went in on vacuum; the last 500 pressure started to build up and they had about 600 pounds pressure on the tubing. Then when the acid was all in, they switched to oil and pumped I believe 25 barrels of oil in that well as a flush. That went in at 600 or 700 pounds. When that was

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done the treatment was over and Mr. Nicholas advised that they leave it shut in for an hour or so. The Mr. Nicholas I refer to was a Halliburton treater and he was in charge of the job. Mr. Nicholas advised either J. E. or W. L. Steelman that the well be shut in for a while. I was present and heard the conversation. I don't remember exactly what Mr. Nicholas said, but that is what he advised and that is what they did. During the treatment of this well, I was present the entire time; also present were J. E. Steelman, W. L. Steelman, Stanley Hamilton, and the two Halliburton men, Nicholas and Aspin.

With respect to the Robert Zahn well which was treated by Halliburton on August 19, 1938, I did not witness the entire treatment of that well. As I remember it was a sort of three-stage affair and I saw only the first stages of it. I was present when the Halliburton men put acid into the well. I went over to the well in the morning. Ralph McCannon was a driller on that well. Pretty soon the Halliburton boys came to the well. Nicholas came in a Halliburton coupe; a couple of other fellows I had never seen before came in the Halliburton coupe. I later found out their names were Anthony and Swain. The acid came in a Halliburton truck and trailer, 2000-gallon capacity outfit. It was driven, I believe, by a fellow by the name of Campbell. They checked the casing, annular space again, put a gauge on it, hooked their cable up from the truck to the well head, and pumped about three gallons of this blanket in first and immediately followed that with 250 gallons of acid. Then they followed that with oil. I believe they pumped about 11 barrels of oil on top of that. They got up a little pressure getting the last of that oil in. Then they recommended that the well be shut in for over the noon hour is what it amounted to. About one o'clock they came back and directed McCannon and me to start swabbing the well, which we did, and swabbed it down to about as dry as we could get it, hooked the pipe back on to it, pumped in about 500 gallons of acid, and flushed the tubing again with oil to the tune of about 12 or 14 barrels. Just about that stage of

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the game is when I left. I stayed there possibly for a little bit of the swabbing. A swab is a little rod with rubber cups on it you run down the well. You run it down on a cable, goes through the fluid and when you pull it back out it has valves in it which close and this raises the column of fluid in the well. It is about the same as either producing a well or getting the fluid out of it. During the treatment of this well, W. L. Steelman was present most of the time and J. E. Steelman was present off and on, and that was also true with respect to the Wilcox well. There were conversations between the Halliburton representatives and the Weber Oil Company representatives which had to do with putting the well back on production. Mr. Nicholas made about the same suggestion as before, namely, that the well be left for a period of time, about an hour, as I recall, before they started swabbing again. He made that statement either to the driller or W. L. Steelman, I don't remember which, but I do recall that such a statement was made by Nicholas.

I was present during the entire time that the Weber Oil Company's Crawford Well No. 5 was being treated by Halliburton on September 10, 1938, and I observed the treatment. I went over to the well about seven or seven-thirty in the morning, and Ralph McCannon, the driller that had been on the Zahn well, was over there, and also a fellow helping him, and shortly after that W. L. Steelman came to the well. We changed the casing head and hooked the thing up so it was ready to be treated. Shortly after that Nicholas came to the well with his Halliburton coupe. Then he and Mr. Steelman left the well and went back to try to get the truck and trailer out of the mud, which took them until about ten-thirty. Finally they got it over there and they hooked the pump up to the well head, and hooked a section of the pump to a tank of oil sitting there about 100 feet away from the well, and started to pump oil into the tubing with the casing open. This well didn't have a packer. They continued to pump oil until the well was full, as evidenced by oil coming out of the casing head. That took about 41

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barrels of oil. Then they mixed their blanket, or else it was already mixed—I don't remember specifically on this well—and pumped about 10 gallons of blanket into the tubing. They followed that with 450 gallons of acid and then they shut down for about five minutes, according to Nicholas, to let the blanket drain out and get down to the bottom of the well; then pumped another 10 gallons of acid to fill up the space in the well over the pay formation, all this time circulating oil back to the casing head. I forgot to mention they had a line from the casing head back to the oil storage tank. They continued to pump acid at a very slow rate with about 200 or 300 pounds on the tubing, with about 700 or 800 pounds on the casing, until they had pumped the entire 2000 gallons of acid into the well. Then they went back on oil, flushed the tubing with about 12 or 14 barrels of oil on top of the acid. At the end of that pumping, the pressure on the tubing and casing was equalized to about 700 pounds. The 450 gallons of acid was of such volume that it was calculated to just fill the tubing. I don't know exactly what the depth of the tubing was, but it was somewhere around 1600 feet, and that is close to the volume of acid it takes to fill the tubing at that depth. At the conclusion of this well treatment, Mr. Nicholas said he would leave the well set there a couple of hours and then put it back onto production. This statement was made to Mr. Wesley Steelman or Mr. McCannon. I cannot remember which, but I was present when Mr. Nicholas made this statement.

In the treatment of all three of these wells, the blanket was introduced into the bottom of the well. It was put into the tubing ahead of everything else and was pumped to the bottom. The blanket was put into the well in each instance before the acid, and that is true of all three treatments.

While present observing these three treatments, I noticed that Halliburton had an electrical cable hooked up in each instance. I don't believe I mentioned that on the Crawford well, but during the pumping of the 450 gallons of acid I was talking about, they got the cable out, and strung it to the tank and connected it to the tubing head. Such a

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connection was made at some time or another during my stay at all three of these well treatments. This connection consisted of about one-half inch copper cable with rubber insulation. The cable connected the tubing head to the tank, so far as I could see, and it was also connected to something on the tank. That is, one end of the cable was connected to the tank, and the other end to the tubing head. Of the men I have mentioned, Nicholas, Swain and Campbell were Halliburton representatives, while J. E. Steelman, W. L. Steelman and McCannon worked for the Weber Oil Company. I am able to remember the exact details of the treatments of these three wells because just as soon as I came away from a treatment I wrote it up while it was fresh in my mind, and I have had access to those notes to keep my memory fresh.

The way in which I happened to be present during the treatment of these wells, the Wilcox, Zahn and Crawford, was that Mr. Conner asked me to go to these jobs and see if I could find out what was going on, to watch the treatments and get samples of the materials put into the wells if possible. Apparently through Mr. Conner's arrangement, I made contact with J. E. Steelman, the Weber superintendent in that district, and it was all right with him so I went out to the wells. I was present during the treatments of these wells for the purpose of observing the treatments and obtaining samples.

I obtained samples of acid used in treating the Crawford well on September 10, 1938. Before Halliburton started to pump any acid into this well Mr. Steelman brought a couple of one-gallon stoneware jugs over to the well and asked Nicholas if he would fill them up for his father, J. E. Steelman. The jugs sat around there for a while. During the period when they were circulating their tanks to mix some of the ingredients they put into the acid, they opened up a little auxiliary suction line on the pump and drained the acid into the jugs. Along towards the latter part of the afternoon J. E. Steelman came over to the well, picked up the jugs, and took them away. I saw

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J. E. Steelman obtain that sample of acid. I saw the whole thing; everything that happened. Later I obtained possession of the acid sample. After the treatment was over, I went to J. E. Steelman's house where he had taken the jugs of acid. There I met E. C. Hardy, a Dowell engineer, and in Hardy's presence Mr. Steelman turned the jugs of acid over to me. I split the sample of acid into four samples which I put into half-gallon glass-stoppered bottles and proceeded to seal the samples and to label them as to what they were and where they came from. I wrote the labels out myself and they bore my signature as having witnessed the taking of the sample. I think Mr. J. E. Steelman also signed the label as having taken the sample and probably W. L. Steelman as having witnessed that, but I cannot be too sure. The labels stated that the contents were samples of hydrochloric acid which were obtained from the Halliburton trucks on the treatment of the Crawford Well No. 5, treated September 10, 1938, and that the contents were samples of the materials put into the well by Halliburton. The containers into which these acid samples were put were two one-gallon stoneware jugs, and when the samples later that day were turned over to me by J. E. Steelman, they were in exactly the same containers as when he took them, namely, one-gallon stoneware jugs. After receiving these samples and putting them in four half-gallon glass-stoppered bottles and labeling them, Mr. Hardy and I brought them to Midland, Michigan, and got in touch with Mrs. Rose Gilroy of Mr. Campbell's office. She came to the office and opened up the vault and locked the samples in it. That was done on the same day, September 10, 1938.

When the Weber Oil Company's Zahn Well was treated by Halliburton on August 19, 1938, I also obtained samples of the acid used by Halliburton in treating this well. At J. E. Steelman's house we again met Mr. Hardy and I proceeded to transfer the acid into half-gallon glass-stoppered bottles and sealed and labeled them. I labeled these samples as being hydrochloric acid obtained from the truck tank of the Halliburton acidizing truck on August 19, 1938,

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during the treatment of the Robert Zahn Well No. 2. I signed that label myself, I think, as having taken the sample. W. L. Steelman was there at the time we got the sample and he witnessed it. This acid sample which was obtained when the Zahn well was treated was in my possession all the time. I requested the sample, saw it taken, and had it in my possession all the time.

When the Weber Oil Company's Wilcox well was treated by Halliburton Oil Well Cementing Company on August 5, 1938, we obtained samples of the acid used by Halliburton in treating this well. In this instance J. E. Steelman brought his two one-gallon stoneware jugs over to the well and asked Nicholas if he would fill them up. They were filled right out of the Halliburton tank on the truck. That was before they had ever pumped any acid into the well. This was in the morning. I can't remember who took the samples away, but they were taken to J. E. Steelman's house and transferred to glass bottles, sealed and labeled, the same as the others. In both cases, I think it was the Halliburton driver who took the acid sample out of the Halliburton tank. Either W. L. or J. E. Steelman, I don't remember which one, transferred the acid samples from the well site over to J. E. Steelman's house, where I then put the samples into bottles and labeled them as hydrochloric acid obtained from the Halliburton truck on August 5, 1938, and being the same as the material furnished by Halliburton and put into the Weber Oil Company's Wilcox well. I signed the labels and one or the other of the Messrs. Steelman also signed them.

The samples obtained on August 5, Mr. Hardy and I brought to the office of The Dow Chemical Company at Midland, Michigan, and turned over to Mrs. Rose Gilroy, who locked them in the office vault in our presence. In each instance, the bottles used were brand new bottles which we had procured from the stock room in the Dow Plant. They were new bottles and absolutely clean. I know that the stoneware jugs in which the samples were obtained at the well were clean because I washed them out every time I used them.

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With respect to the samples obtained on August 5, 1938, when the Halliburton Oil Well Cementing Company treated the Weber Oil Company's Stella Wilcox No. 3 well, I transported those samples to Midland, Michigan, on that date and I believe I turned them over to Mrs. Rose Gilroy. Likewise, when the Weber Oil Company's Crawford Well was treated on September 10, 1938, by Halliburton Oil Well Cementing Company, I transferred those samples to Midland, Michigan, on that date and likewise turned them over to Mrs. Rose Gilroy. On August 19, 1938, when the Halliburton Oil Well Cementing Company treated the Weber Oil Company's Robert Zahn well and I obtained samples of the acid used, I transferred these samples to Midland, Michigan, and that night locked them in Building 280 at the Dow Plant, and on August 29, 1938, I deposited these samples in the vault of The Dow Chemical Company's office at Midland, Michigan. At that time I think I turned them over to Mrs. Rose Gilroy. It was in the daytime and Mr. Conner and I took them over to the vault. When samples were obtained from the Zahn, Wilcox and Crawford wells, I saw that the samples were deposited in the main offices of The Dow Chemical Company at Midland, Michigan.

I had something to do with samples of materials which were marked Nos. 14 and 20. These were samples that were brought to the office in glass jars. I do not know exactly when these samples were brought in, but one set had a date on the label of August 18, 1938, and the other set bore on the label the date of December 6, 1938, I believe it was. They were samples of hydrochloric acid, which, according to the labels, had been obtained from the north and south storage tanks of the Halliburton Oil Well Cementing Company's station at Mt. Pleasant, Michigan. These labels were signed by Mr. Day and Mr. Forsman. There was a total of four samples, two marked August 18, 1938, and two marked December 6, 1938, coming from both the north and south tanks on each of these days. I transferred these samples into glass bottles so that they could be sealed, and relabeled them and signed the labels as having made the

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transfer. I do not recall anything about who may have brought the samples to the Midland office. I simply re-labeled them. The label I applied to these bottles carried my signature. The data which I put on these labels I obtained from a sticker on the jar in which the sample was originally contained and which identified the sample. So far as I know, Mr. Conner gave me those samples for the purpose of rebottling and relabeling.

CROSS EXAMINATION

When the Wilcox and Zahn wells were treated, a packer was employed. I know that because it was common knowledge that there was a packer on these wells. The packer was on the tubing and the acid went below the packer, so that if the packer held in these Wilcox and Zahn wells, the acid would not come in contact with the casing pipe. The first 1500 gallons of acid went in pretty fast, but the last 500 gallons went in slowly. I would say that the acid was in contact with the tubing at least an hour. In the only treatments I saw on the Zahn well, the acid would not have been in contact with the tubing over an hour or two.

Two sets of the acid samples obtained came directly from the Halliburton truck tanks. The other set of acid samples was taken when they were circulating. They had used Klersol, and had circulated the tank for at least five minutes and were in the process of mixing Klersol into the truck or trailer tank. Somebody said this would be a good time to get the sample. They opened up the drain. This was on the Crawford well.

By Mr. Babcock:

Q. I want to know whether the sample would be truly representative of what Halliburton hauled out to the well or whether it would be contaminated by, say, some of the oils, mercaptans, or other things in the well? A. There is no question of that in my eyes. Two of the samples came out of the tank, the other acid sample came out of circulation

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from the bottom of the tank. There would be no possibility for any contamination of any sort.

We used the same stoneware jugs each time. The first time we used them they were brand new, and as we finished transferring the acid from them we washed them out good, stoppered them, and put them away until we got ready to use them again. Whether they were rinsed again I do not know. These stoneware jugs had never been used for anything else in their lives from the time they were new until they got into this deal. I do not know whether the samples of acid I took were samples of inhibited acid or not. I had nothing to do with the testing of this acid.

In the Wilcox, Zahn and Crawford wells, oil was being produced from the Dundee formation in two of these wells, and I am not sure whether it was being produced from the Dundee or Traverse in the other. I believe it was from the Dundee formation in all of them. The Traverse formation is also limestone. Previous to the three well treatments to which I refer, Halliburton Oil Well Cementing Company had made one other well treatment for the Weber Oil Company that I know of.

The Messrs. Steelman that I refer to are father and son, and I would definitely say that they were oil men. The Weber Oil Company's driller probably knew something about oil. I do not think that Mr. Nicholas had to instruct the Weber Oil Company's representatives with respect to treating these wells. I think Mr. Nicholas offered information as a suggestion which the Weber men were perfectly willing to follow. Even though they are oil men, it is sort of general practice for most oil men, especially smaller outfits, to pretty nearly accept the recommendations of the acidizing or service company as to what they are going to do to a particular well. My impression is that they feel like the service companies know more about treating their well than they do, from the service end of it.

Q. How do you regard the statements of Nicholas as to how long the well should remain shut in after the acid was introduced, as to what he thought to be the best practice? A. Well, it was a little more than that, although I

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feel, absolutely, if either of the Messrs. Steelman had had any instructions from Weber Oil Company, they probably would have followed those in preference to Nicholas' suggestions. Nicholas made the statements in such a way it appeared he intended the well to be shut in as he said.

This conversation between Nicholas and the Weber Oil Company's representatives took place at the Zahn well, between the stages of treating it. It was noon and they all left and went to lunch during the shut-in period. The second time Mr. Nicholas suggested that the Zahn well be shut in, I was there and it was during the second shut-down period of the Zahn well treatment. I stayed there and just started to swab the well when Mr. Steelman came and said, "Let's go." On the Crawford well the treatment was all over and they left. I left too. The well was necessarily shut down because it would take them longer than that to run the rods into the well and get the well to produce. They didn't start to do that immediately.

I have no knowledge of what happened on any of these wells after the acid was placed into the well and after Halliburton left except in the case of between the stages of the treatments on the Zahn well. I don't know what happened on the other wells. On the stage treatment of the Zahn well, the acid was forced into the formation, withdrawn, and then a new batch of acid was forced in and withdrawn. The spent acid was removed at the end of the first stage by swabbing the well for about an hour until we couldn't get any more fluid out of the well. I do not know how much spent acid we got out of the well. Mr. McCannon of the Weber Oil Company and I did the swabbing.

When the Weber Oil Company's Stella Wilcox well was treated August 5, 1938, by the Halliburton Oil Well Cementing Company, the acid in the tank was not circulated or stirred up, and we got the sample of acid out of the truck tank in the morning, before Halliburton had pumped any acid into the well.

By Mr. Babcock:

Q. So, in your opinion, there couldn't have been any

Paul G. Shelley

contamination, no mixture of acid? A. No, not in that case, or any of them, but specifically it wasn't possible for anything to be in that jug that wasn't in the tank. There may have been oil in the tank they had gotten somewhere else—I don't know anything about that, but so far as the acid that went into the well it was the acid that Halliburton brought to the well.

Q. Did you look into the tank? A. I think so, yes.

Q. But you don't remember whether there was any oil on the surface of the acid or on the walls of the tank? A. Well, I just can't be absolutely sure about it. I just didn't have that in mind at the time. There probably was skim oil on it. You can hardly find a tank that there isn't skim oil on it.

Q. Is it customary in these acidizing jobs to circulate oil through the tanks sometimes? A. Well, sometimes it is customary to get oil in the tank, sometimes in the pumps. You pump oil to flush your pump out after you finish, flush the tubing, and then flush the pump. You drain it but if you are trying to establish the fact there is the possibility there may have been oil in the tank, the answer to that question is yes. It is impossible to keep all the oil out unless you bring the acid all in glass jugs. There was nothing taken from this treatment except the material that got into the jug.

Q. On the Crawford well was the same pump and same tubing used to circulate the acid that was used in the treatment to pump the oil? A. Same pump.

Q. Same tubing too? Part of the same tubing? A. No, they usually hook another hose on the side of the tank, circulate it. They make pipe connections from the well.

When the Weber Oil Company's Zahn well was treated by Halliburton Oil Well Cementing Company on August 19, 1938, the acid samples were obtained in the interval between the two stages of treating this well. The acid sample was given to me by one of the Halliburton men, upon request, who took it from the manhole of the Halliburton truck tank. On this well we did not swab any oil or acid back into the

Paul G. Shelley

Halliburton truck tank. We did not circulate the acid back into the Halliburton tanks. We didn't circulate anything back into the Halliburton tanks. The procedure on the Zahn well was to pump 3 gallons of blanket into the well, which was followed by 250 gallons of acid, then followed by about 10 or 12 barrels of oil. The well was then shut down for a while after which it was swabbed, but we swabbed back into the Weber Oil Company's lease tank. It was not a matter of circulation, it was a matter of cleaning the well out to get the spent acid back by swabbing it out. The spent acid went into the Weber lease tank. Then, on the second stage of the treatment of this well, more blanket was put in, about 5 gallons of blanket and 500 gallons of new acid and we did the same thing over again. The oil that followed the acid went back into the Weber lease tank. (Witness refers to notes.) On the second stage of this treatment we did exactly the same thing. A sample of the acid was taken between the two stages. It was then taken out of the Halliburton truck tank. Never had there been any opportunity for anything to get into the Halliburton truck tank at all. In other words, the material in the Halliburton truck tank didn't have any opportunity to be contaminated with anything that had been in the pump because nothing circulated from the pump back into the Halliburton truck tank. This Zahn well was the instance where I asked the Halliburton man to get the acid sample out of the Halliburton tank.

With respect to the acid sample obtained when Halliburton treated the Weber Oil Company's Crawford well on September 10, 1938, the sample was taken before any acid was pumped and during a period of circulation. Whether it was taken before or after pumping oil I would not know. (Witness refers to notes.) The acid sample from the Crawford well was taken after the oil had been pumped. This sample was taken from the pump after we had finished pumping oil and had circulated the tank. A blanket was also used in this treatment. The blanket was put into the well and then followed with acid. There was no packer

Paul G. Shelley

in this Crawford well; the well hole was filled with oil prior to the treatment, and we forced the oil into the well to place the blanket into position and circulated the oil back into the lease tank by means of the Halliburton pump. Then, with the Halliburton pump, we pumped oil from the lease tank into the well tubing until the casing, tubing and all of the well was full of oil. Then, I think it was that we started mixing up the acid, but I cannot be too sure of that until I check. (Witness refers to notes.) Yes, we finished pumping oil and then mixed chemicals and circulated them with the Halliburton pump. This circulation consisted of taking suction out of the bottom of the Halliburton tank and running the acid through the Halliburton pump and back into the Halliburton tank it came from.

RE-DIRECT EXAMINATION

As to how long the acid was in contact with the tubing during the treatment of the Crawford well, four hours would be within 20 per cent right. I would absolutely say, with respect to all the acid samples I obtained, that there is no doubt but what the samples were absolutely representative of the material that went into the oil wells. Had I not taken the samples of acid coming from the Halliburton tanks, that same acid would have been put into the oil wells.

RE-CROSS EXAMINATION

By Mr. Babcock:

Q. In the Crawford well, it's a cinch, as far as I can see, what went into the well from the Halliburton tank wasn't only some acid but also some oil that came out of the well, isn't that true? A. Well, that's possibly true, yes. There might have been a little oil left in the pump.

Q. I am only speaking of a little, but it's a cinch some oil that was circulated got into there? A. Yes, you open up the drain, there is some oil that sticks in the pump, a little oil held up over the valves. It would be silly to maintain the acid was absolutely completely oil-free.

Joseph E. Steelman

JOSEPH E. STEELMAN,

a witness, called by plaintiff, testified as follows by deposition:

DIRECT EXAMINATION

I live at West Branch, Michigan, am an oil field superintendent for the Weber Oil Company of Bay City, Michigan, and have worked for them since July 30, 1933. My duties include superintending the drilling and producing of crude oil for the Weber Oil Company, and I have charge of the Weber Oil Company's wells in Ogemaw County, Michigan, and elsewhere.

It is the practice of the Weber Oil Company to have its wells treated with acid and this work has been done by Dowell Incorporated and Halliburton Oil Well Cementing Company. The Weber Oil Company owns and operates in Ogemaw County, Michigan, wells known as the Wilcox No. 3, Zahn No. 2 and the Crawford No. 5. My records show that Halliburton Oil Well Cementing Company acid treated the Stella Wilcox Well No. 3 on August 2 and August 5, 1938, the Robert Zahn Well No. 2 on August 19, 1938, and the Crawford Well No. 5 on September 10, 1938.

On August 5, when the Stella Wilcox Well was acid treated by Halliburton, Paul Shelley received from me samples of the acid used in treating that well. The acid sample was taken out of the tank by one of the Halliburton men, I believe, and handed to him. I took the samples to my garage so that they wouldn't be broken or destroyed at the well and gave them to Paul Shelley. He took the samples from my garage, which was not probably more than an eighth of a mile from the well, and it was there at my garage that I gave the samples to Shelley.

Again, when Halliburton treated the Zahn well on August 19, we obtained samples of the acid used. I took the sample home to take care of it until Shelley came and got it. In each instance when I took the sample from the well

Joseph E. Steelman

to my house, the sample did not leave my possession until I gave it to Mr. Shelley. From the time that I obtained the samples at the well and took them to my house and turned them over to Shelley, I did not add anything to them and they did not leave my possession.

I have in my possession records which will show the production of the Wilcox well before it was acidized on August 5, and also its production after it was acidized. I will give the production figures in feet and inches and also the rate of barrels to the foot, and you can do the actual figuring. On July 28 the Stella Wilcox made 1 foot 1 inch of oil in a 100-barrel tank that we estimate makes 10 barrels to the foot. On July 29 it made 1 foot even in a 100-barrel tank. On July 30 it made 1 foot. On July 31 it made 1 foot. August 1 there was no production for the reason that we had to run tubing to use in acidizing the well. On August 2 we swabbed a foot of oil, that is before you start putting the acid in. On August 3 the well made 5 feet 1½ inches in a 100-barrel tank. On August 4 it made 4 feet. On August 5 it made 3 feet 10 inches. Of course, as all acidizing men know, that figure on August 3 contained a lot of acid in there and water. August 6 production shows 10 feet 6 inches in a 100-barrel tank. August 7 shows 5 feet 8 inches. There is a blur on my record for August 8, but it looks like the well made 2 feet 3 inches. On August 9 it made 4 feet 1 inch. On August 10 all the production shows here is 2 inches in a 500-barrel tank. Now, get the difference because that 2 inches here is in a 500-barrel tank. August 11 it doesn't show any production. That is the end of the production records for that well because on August 12 they pulled the rigging down. The production records show that as a result of acid treating this well the production was increased probably by two-thirds for at least thirty days.

I have similar records showing the production of the Zahn Well No. 2, which was acidized by Halliburton on August 19, 1938. These records begin on August 6, on which date the well made 3 inches in a 100-barrel tank. On

Joseph E. Steelman

August 5 the well made 5 inches. On August 6 it made 6 inches. August 9, 6 inches. On August 10, it made 2 inches. August 11 it made 5 inches. August 12 it made 2 inches. August 13, 4 inches. August 14, 4½ inches. August 15 it made 4 inches, and August 16 the same amount. That is the end of that period of production because we had taken down the well rigging. I have production records here that show the well was treated on August 19, 1938. The record for August 20 doesn't show any production at all. The record shows that for August 21 the production was 3 feet 2 inches, which also includes part of 1 foot 11 inches of oil put down into the well when acidizing it. The next production record I have for this well is for August 23, showing the well produced 3 feet 11 inches in a 100-barrel tank. On August 24 the production is 2 feet. There was no production on August 26 because we were pulling the tubing and taking the packer off and rearranging the pumping equipment. The next production record I have for this well is on August 15, 1938. I have no production records for this well for September as we were constructing a new tower on that well at that time and we had quite a delay. I have production records on the Zahn well which show its production after it was put on the pump. These records start with October 15, 1938, and show that on that date the well made 10 inches in a 250-barrel tank. On October 16 it made 7 inches in the same tank. October 18 it made 4 inches. October 19, 5 inches. October 20 it made 3 inches. October 23, 2 inches. October 25, 1 inch. October 26, 4 inches. October 27, 3 inches. October 28, 5 inches. October 29, 4 inches. October 30, 3 inches.

I also have production records on the Crawford Well No. 5 which show its production before it was acidized on September 10, 1938. On September 1 this well made 10 inches of oil in a 100-barrel tank. On September 2 it made 10 inches. September 3, 11 inches. September 5 it made 1 foot 5. September 6, 8 inches. September 7, 8 inches. September 8, 3 inches; we were running tubing that day. September 10 the well was acidized and we used about 5

Joseph E. Steelman

feet of oil from a 100-barrel tank. On September 11 the well made 4 feet 1½ inches in a 500-barrel tank. September 12 the well made 3 feet in a 500-barrel tank. September 13 it made 2 feet 6 inches. September 14 it made 1 foot 9 inches. September 15, 2 feet 2 inches. The records then show the well was closed down for want of tank room.

I was present at intervals during the treatment by Halliburton of these three wells. I was at the well part of the time, what time I could spare from my daily routine duties. To the best of my memory, I was present at the conclusion of the treatments. I have many other duties in this field and on the days these wells were treated I divided my time. But I was present at least part of the time. I don't recall any conversations at the conclusion of these treatments between myself and the Halliburton men who were treating the well which had anything to do with putting this well back onto production. I don't recall hearing anything out of the ordinary whatsoever, maybe just some suggestion about how to fix the line or something. At this time I don't recall any suggestions or discussions with the Halliburton men about what next to do to the well, about bringing it back to production.

CROSS EXAMINATION

As to the kind of packer we used, it was just a rubber expanded Larkin wall packer. Halliburton did not do anything to protect our tubing from corrosion, so far as I know. If they did, I did not know what it was. I don't know how they could do anything to protect the tubing. To my knowledge, they never any of them do. Halliburton has not acidized any wells for the Weber Oil Company other than these three. I recall how I happened to select Halliburton to acidize these three wells. It was at the request of Dowell Incorporated. Also, we were interested to know if Halliburton's treatment would be any better. We are always looking for improvements.

William S. Day

WILLIAM S. DAY,

a witness called by plaintiff, testified as follows, by deposition:

DIRECT EXAMINATION

My address is Mt. Pleasant, Michigan, Route No. 4. I am district manager for Dowell Incorporated, whose business is that of acidizing oil wells. My territory covers Michigan, part of Ohio and Canada.

The Halliburton Oil Well Cementing Company is located in Mt. Pleasant, Michigan, and their business is also that of acidizing oil wells. That company did have two wooden storage tanks at Mt. Pleasant. They have one steel storage tank now. I saw the wooden storage tanks of Halliburton's up until about six or eight months ago. I have seen these tanks on several occasions; they were located on North Franklin Street and contained hydrochloric acid. I know this because on two different occasions I got samples out of them. These tanks set right alongside of each other, one north, and one south, which I refer to as the north and south tanks.

The first occasion I obtained samples from these tanks was on August 18, 1938. I took the samples to my office, labeled them, locked them up, and brought them to the office of the Dow Chemical Company at Midland, Michigan, where I gave them to Mr. Conner. I labeled the acid as being taken out of Halliburton's tank on that date and I had the date on the sticker. I also designated whether the sample came from the north or south tank to identify the tank to which the sticker referred. I signed the labels.

I obtained other samples from both these tanks on December 6, 1938. I disposed of these samples in the same manner as the first. These samples contained labels the same as the first samples and I signed the labels.

In each instance the sample of acid I obtained from each tank was about two or three quarts. Whatever sam-

William S. Day

ples I took from these tanks I delivered to Mr. Conner at Midland, Michigan. When I obtained these samples Warner Forsman, bookkeeper in our station office at Mt. Pleasant, was with me each time, and he was with me each time I delivered the samples to Mr. Conner. When I obtained these samples on August 18, 1938, and December 6, 1938, I got the samples in a new clean glass jug.

CROSS EXAMINATION

These wooden tanks had no oil around them or anything in them besides acid. They were just hydrochloric storage tanks of 250 barrel capacity. When we (Dowell) come back from the well and have not used all of the acid in our truck tank, we never pump it back into our storage tank. My recollection is that these Halliburton tanks had no oil around or in them at any time I took the samples.

I got the samples through the manhole cover in the top. No Halliburton men were there, if there had been I would have asked them for the samples.

RE-DIRECT EXAMINATION

I recognize the top picture of PX-168 as being the Halliburton storage tanks located at Mt. Pleasant, Michigan. The storage tanks depicted in that picture are the same ones from which I obtained samples on two different occasions.

Warner Forsman

WARNER FORSMAN,

a witness called by plaintiff, testified as follows, by deposition:

DIRECT EXAMINATION

I am district office manager for Dowell Incorporated at Mt. Pleasant, Michigan. I have been employed by Dowell for approximately four years. Dowell is engaged in oil well acidizing and cementing.

The Halliburton Oil Well Cementing Company have an office at Mt. Pleasant, Michigan, and are also engaged in the business of acidizing wells. On numerous occasions I have seen the Halliburton storage tanks located on North Franklin Street. I recognize the top photograph in PX-168 as being a picture of the Halliburton acid storage tanks I refer to. These tanks contain hydrochloric acid. I know this because they are similar to Dowell's tanks which are used for the same purpose. I have seen Halliburton's trucks load acid out of these tanks and we have also obtained samples from these tanks. There are two tanks. I would identify them as north and south, as one tank lies directly north of the other. I have obtained samples from both tanks on two occasions. The first was on August 18, 1938, the second on December 6, 1938. On each occasion I obtained approximately three-quarters of a gallon of acid from both the north and south tanks.

When the samples were taken, they were immediately identified as to which tank they were obtained from and they were delivered to The Dow Chemical Company at Midland, Michigan, to Don Conner. The samples were identified by labeling each sample with respect to the location of the tank. We marked the first sample we obtained in August N-14 and S-14. They were labeled over here and we signed our names to the labels indicating the tank from which each sample was obtained.

On August 18, 1938, I got a sample from both the north and south tank and these samples were put in separate con-

Warner Forsman

ainers. The labels showed the dates on which the samples were obtained and bore the signatures of W. S. Day and Warner Forsman. Similarly in obtaining the samples on December 6, 1938, each bottle was labeled in a like manner and bore my signature and that of Day. After obtaining these samples on both occasions they were brought to Dowell's office, and delivered to The Dow Chemical Company's office within ten hours from the time they were obtained and delivered to Don Conner.

CROSS EXAMINATION

Q. How did you obtain these samples? A. They were obtained in a clean glass jar.

Q. I mean did you get them out of the top of the tank? A. Yes.

Q. Who climbed up on top of the tank? A. I guess I did.

Q. Did you put old clothes on? A. I was working around the garage. I was asked if I wanted to go down the street. I said yes. I didn't have any clothes for it.

Q. What do the tanks look like? A. Wooden storage tanks.

Q. Any oil on them, around them or in them? A. I didn't notice any oil.

Q. How did the acid look? Did it look clear and clean? A. Yes.

Q. What time of day was it? A. I don't remember exactly. It was probably, oh, around dusk, probably eight or nine o'clock.

Q. Eight or nine o'clock in December in Michigan you can see what acid looks like in a tank? A. No. It might have been later than that. I don't remember the exact time.

Q. Well, you don't know what it looked like inside the tank then, do you? A. No, I thought you meant when I got the acid out. You can't, of course, see down a tank.

Q. What did you lower into the tank? A. Lowered a clean glass quart jar.

Q. Did you have it on a bail or hook or something? A. Yes.

Rose Gilroy

ROSE GILROY,

a witness called by plaintiff, testified as follows, by deposition:

DIRECT EXAMINATION

I live at 1713 Sayre Street, Midland, Michigan, and am secretary to the general counsel of The Dow Chemical Company. I remember one night in August, 1938, that Mr. Shelley and Mr. Hardy and Mr. Conner met me at the offices of The Dow Chemical Company in Midland with samples in glass bottles. These samples were put in the vault of the Legal Department. Then I locked the vault in their presence. That was in August, 1938. I have a way of fixing the date because I was called away from a dinner party. The samples consisted of a number of glass bottles which were labeled. I do not know who labeled them or what was in them. The contents of the bottles were liquid.

That is not the only occasion on which Mr. Shelley, Mr. Hardy or Mr. Conner delivered samples to me. About a month or so later, these gentlemen brought another quantity of labeled glass bottles and these also were put in the vault in the presence of these gentlemen. That was in 1938. I cannot give the month, but I would say about a month or so after the first batch.

Leonard C. Chamberlain

LEONARD C. CHAMBERLAIN,

a witness called by plaintiff, testified as follows, by deposition:

DIRECT EXAMINATION

I live in Midland, Michigan, and have been employed by The Dow Chemical Company since 1928 as a research engineer. During the month of June, 1939, I attended the taking of depositions at Mt. Pleasant, Michigan, in this case and obtained a piece of lead from defendant. When the depositions were over, we went to the Halliburton warehouse at Mt. Pleasant, where one of the Halliburton men gave me this lead strip. I put it in my car and brought it back to Midland and tagged it with pertinent information concerning where I obtained it and put it in the vault here in Midland. I prepared a label for the lead strip so it could later be identified, which label contained the information that this lead strip was obtained that day from the Halliburton Oil Well Cementing Company representative and that I received it and brought it to Midland. I signed the label and attached it to the lead strip. This lead strip was put in the vault in the office of Mr. Campbell.

Q. Do you know the name of the party representing Halliburton who gave you the lead strip? A. Well, there were several of them there. I think Mr. Edwards was there.

Q. Mr. Edwards is here today. Is he the gentleman?

A. I think you were there (witness addressing Mr. Conner). I think Babcock and Edwards were both there.

Witness (to Mr. Babcock): Weren't you there?

Mr. Babcock: I actually don't know that we gave you one there. I mailed you one.

By Mr. Conner:

During the depositions in 1939 in Mt. Pleasant you offered us a lead strip such as is used in the tank as an

Leonard C. Chamberlain

electrode, and we accepted it according to the testimony of Mr. Chamberlain.

Q. At the time this lead strip was given to you what, if anything, was said to you by any of the Halliburton representatives as to the use that they made of such or similar lead strips? A. Well, it was the remainder of a strip which they said they hung in their tanks during the polarization of the tanks.

Q. Was this a strip which had or had not been used, do you know? A. It was supposed to have been used.

CROSS EXAMINATION

I did not test this lead strip to see what it was chemically. I do not know where the lead strip is now.

DONALD L. CONNER,

a witness produced on behalf of plaintiff, testified as follows:

DIRECT EXAMINATION

I live in Tulsa, Oklahoma, and am a lawyer employed by The Dow Chemical Company, stationed at Tulsa, Oklahoma. I am the Mr. Conner to whom several witnesses have testified they delivered certain samples.

On August 5, 1938, E. G. Hardy and myself met Paul Shelley and Messrs. W. L. and J. E. Steelman at the home

Donald L. Conner

of J. E. Steelman outside West Branch, Michigan. We met them late in the afternoon as I recall, and J. E. Steelman, I think, turned over to Mr. Shelley two stoneware jugs of liquid. I was present when Mr. Steelman turned these jugs over to Shelley and Hardy. These two jugs, which I was told contained liquid hydrochloric acid, were put into four one-half gallon jugs with glass stoppers and sealed. I observed Shelley write out labels for each of these four bottles of acid which had come from the jugs. The labels, which I saw him write and have observed since, showed what acid it was, where it came from, who supplied the acid, identified the well, and gave the date. Those samples were sealed. Shelley signed each one of them and Hardy signed the label in each instance, showing Shelley had sealed the sample and that Hardy was a witness to the sealing of the sample. In this case, the Stella Wilcox well, Mr. Steelman signed the label. That gave us four one-half gallon jars of acid as samples taken from the treatment of that well. I was present at Mr. Steelman's home when the jugs of acid were brought in from the well.

In each instance, when the Wilcox well was treated on August 5th, the Zahn well on August 19th, and the Crawford well on September 10th, for the Weber Oil Company by Halliburton, I was present in Mr. Steelman's yard, and either Mr. Steelman turned the samples over to Shelley or Shelley brought the sample with him. I want to correct my testimony. I was not present when the samples from the Zahn well were delivered, but I was present when the samples were delivered from the Stella Wilcox and the Crawford wells.

I had nothing to do with the preparation of the labels so far as the physical making of the labels was concerned, but I did direct Shelley as to the wording of the labels, and in each case I or Shelley wrote up in the corner of the label a key number which would then enable us to identify and refer to the sample in a more brief manner. In the treatment of the Wilcox well on August 5th, these acid samples put into the one-half gallon bottles were numbered 5, 6, 7 and 8.

Donald L. Conner

I am pretty sure I was not present at the Zahn well when the samples were taken. I can find out in a few minutes by looking at the expense reports. My recollection is that I was in Oklahoma. I have knowledge of those samples to this extent: I was present in Midland, Michigan, practically all of the summer of 1938. I am pretty sure I must have been here, although I would rather look at my expense records.

(Witness left to examine records.)

My recollection has now returned and I definitely recall that I was not present during the treatment of the Zahn well. I had something to do with the marking of samples, which bore labels indicating that they came from the Zahn well. I recall that during the latter part of August, 1938, when I came to Midland on one of my trips, I contacted Mr. Paul Shelley and he had previously told me that when the Zahn well of Weber's was treated on August 19th he obtained on that date a sample of both the acid and the blanket used in the treatment of that well. Shelley contacted me and together we went into the plant of The Dow Chemical Company to Building No. 280, where we opened up a vault and took out of there some samples that he told me was acid, and some material that he told me was blanket, and we brought them over to the Legal Department office. Those samples of acid and blanket had been labeled in the handwriting of Shelley to show where the materials came from, on what date, what well, who obtained them, and sealed them, and what not. I recall that the label showed there were three one-half gallon bottles and the label said substantially that they were hydrochloric acid, part of the acid put into the Zahn well by the Halliburton Oil Well Cementing Company, and the label went on to say that it was brought to the well by the Halliburton Oil Well Cementing Company, each label was signed by Shelley to show he had sealed them and further signed by E. P. Hardy showing he had witnessed it.

Either I marked or I instructed Shelley to mark up in one corner of the labels on these acid samples, the num-

Donald L. Conner

bers 12, 12A and 12B, there being three one-half gallon samples. Shelley and I, after getting them from 280 Building in the plant, brought them to the vault in the Legal Department office. I was with him when he brought them from 280 Building over to the office, and that was the latter part of August.

I was present at the time samples of acid were obtained from the Crawford well, I was present in the yard of Mr. J. E. Steelman at West Branch or I was present with Shelley and Hardy near the well. I don't recall whether it was actually Mr. Steelman's yard or some place near the well where J. E. Steelman or Wesley Steelman, one of the two, gave to Shelley those two one-gallon stoneware jugs containing the acid. We took those jugs, Shelley, Hardy and myself, and Shelley and Hardy poured the acid out of the stoneware jugs into four one-half gallon bottles, stoppered and sealed them, and prepared labels showing from which well they had obtained them, all similar to the other labels. Those samples were marked as samples Nos. 15, 15A and 15B, and I was with Shelley and Hardy when those samples were delivered to the vault of the Legal Department of The Dow Chemical Company at Midland, Michigan. This was done on the very same date, September 10, 1938, that the samples were taken. I recall that very accurately because I left town that night to go back to Oklahoma.

I had something to do with the samples of acid which were obtained by Mr. Day and Mr. Forsman from the Halliburton storage tanks at Mt. Pleasant. I requested of them some time in August that they obtain samples from the wooden storage tanks of Halliburton, which I was told had acid in them and were located on North Franklin Street, Mt. Pleasant, Michigan, on August 18. I remember that date very clearly because it was the day before the Zahn well was treated, I think. On August 19th, Mr. Day and Mr. Forsman brought to me at the Midland office of The Dow Chemical Company, two bottles containing a liquid which they said was hydrochloric acid, each bottle

Donald L. Conner

having attached to it a sticker. If my memory serves me rightly, it was a white sticker with a red border around it, showing one sample came from the north tank and the other showing it came from the south tank, containing the date on which the samples were obtained, and each of those labels were signed by Day and by Forsman. At the time I first saw the bottles, I examined them and marked up in the corner that one sample that came from the north tank, as 14N, and the one from the south as 14S, and so marked that on each of the labels. On that same date, I think it was, I contacted Paul Shelley and had him come to me at the office and, at my direction, Shelley took the north and south samples, and he split them into three parts, stoppered and sealed them. In addition a label was prepared showing where they came from. That label was put on each of the three portions and Shelley signed it. On one of the portions of the sample, 14S and 14N, there was attached the original label that had been on the containers in which they were delivered. When the 14N sample was split, it was then called N-14 for the first portion, N-14-A for the second portion, and N-14-B for the third portion. With respect to the S-14 sample, when it was split the first portion was marked S-14, the second S-14-A, and the third portion S-14-B, and placed them in the vault; all done on August 19th. Later I received additional samples from Mr. Day.

On December 6th, Mr. Day and Mr. Forsman brought me two samples of what they said was hydrochloric acid in two different containers, each labeled showing where it came from and how they got it. As to those samples, I marked one N-20, showing it came from the north storage tank of the Halliburton Oil Well Cementing Company at Mt. Pleasant, according to the label they had prepared, and the other S-20. On that same day, if not the next, as in the previous case with the series No. 14 samples, we took the two samples marked N-20 and S-20, split each into three portions, the S portions being marked S-20, S-20-A and S-20-B, and the N portions being marked N-20, N-20-A

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and N-20-B. On each of the six portions, there was a label prepared based on a label that was on the original container. Mr. Shelley prepared the label and signed it. On one each of the portions, we attached the label Day and Forsman originally had applied to those samples. After those samples were so marked, Shelley and I put them in the vault of the Legal Department at Midland.

CROSS EXAMINATION

By Mr. Babcock:

Q. Who has access to this vault in Building 280? A. That I don't know. It is in the Physical Research Laboratory Building so far as I remember. I have only been in the plant, oh, probably just on a very few occasions, and I wouldn't have the slightest idea who has access to that vault except Shelley. I would presume Mr. Chamberlain, his superior, would, and other than that I don't know.

REDIRECT EXAMINATION

I have a correction or addition to make to the statement in my testimony yesterday referring to a sample Day delivered to me in December, 1938, as sample No. 20: In December of 1938, Mr. Day and Mr. Forsman delivered to me two bottles of liquid which they said was acid taken from the Halliburton storage tanks at Mt. Pleasant, Michigan. These samples, both of them, were labeled when I received them from Mr. Day and Mr. Forsman and the label showed what date the samples were taken, which was December 6, 1938, the labels further showing where the samples came from and further showing who obtained the samples, and bore the names of Day and Forsman, who both then signed the labels. When I received those samples, Mr. Shelley and I, in splitting them, erroneously marked them as samples Nos. 17-S and N, and it later developed that we already had obtained a sample which we had labeled No. 17, giving us duplicate sample numbers 17.

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To correct that situation, I then directed that these storage samples should be renumbered as series 20. That is, they were then numbered N-20, N-20-A, and N-20-B, and the other portion was numbered S-20, S-20-A, and S-20-B, thus making a correction to our numbering of the samples. However, this change had nothing to do with changing anything on the label, which was a true indication of where the samples came from and what not. When these samples were received by me I did not first mark them N-20 and S-20. I may have made my statement a little incorrect at first. When I first received them I marked them S-17 and N-17, A's and B's to each. Finding I already had among my samples a sample marked N-17, which I had previously obtained, I then corrected this latter set of samples, which were the storage samples, and changed their mark from the series 17 to series 20.

I don't recall the exact time interval after the original marking of the N and S-17 numbers and when I changed them to N-20 and S-20. However, I think it was a very short period of probably two or three days. I then and am now keeping a constant chart of numbers I applied to the samples and I think when revising the list as to the numbers, I found I had already numbered one 17. So I would say roughly it was within two or three days.

Mr. Lyon: I just want to make a remark. Counsel for the plaintiff has now offered the depositions of ten witnesses in regard to formal matter, that is, the obtaining of samples on these four wells which were the subject of a discussion this afternoon, and although these witnesses are available in the district, I am willing that their depositions should be taken with the same force and effect as if they were called to testify, but I would like to reserve my objection to this testimony, the same objection that I am making on this subject.

The Court: You may have that, and I will overrule it and you have an exception.

Mr. Owen: Now, the next step, Your Honor, pertains to the transmission of these samples, which by these depo-

Affidavit of Leonard C. Chamberlain

sitions were traced to the vault of The Dow Chemical Company—the next step is to get them from The Dow Chemical Company into the hands of Dr. Bartell, our expert. We have here some affidavits of some men that they delivered them to Dr. Bartell and his affidavit that he received them.

Mr. Lyon: I am willing that these affidavits should be received in evidence with the same force and effect as if the witnesses named in the affidavits were called and testified to the facts in the affidavits.

The following affidavits of Leonard C. Chamberlain, Donald L. Conner, Edward C. Hardy and Floyd E. Bartell were offered and received in evidence.

AFFIDAVIT OF LEONARD C. CHAMBERLAIN

I am a resident of Midland, in the County of Midland, State of Michigan, my address is Isabella Road, and I am employed by The Dow Chemical Company at Midland, Michigan as a research engineer.

On July 6, 1939, and August 31, 1939, upon instructions from The Dow Chemical Company, Legal Department, I removed certain packages and glass bottles containing samples of materials from the vault in the main office of The Dow Chemical Company at Midland, Michigan, and transported them to Ann Arbor, Michigan, where I delivered them to the office of Dr. Floyd E. Bartell, Department of Physical Chemistry, at the University of Michigan.

Affidavit of Donald L. Conner

AFFIDAVIT OF DONALD L. CONNER

I am a resident of Tulsa, in the County of Tulsa, State of Oklahoma, my address is 215 East 27th Street, and I am employed by The Dow Chemical Company of Midland, Michigan, as a lawyer.

On August 24, 1938, and April 25, 1939, I removed certain glass bottles containing samples of materials from the vault in the main office of The Dow Chemical Company at Midland, Michigan, and transported them to Ann Arbor, Michigan, where I delivered them to the office of Dr. Floyd E. Bartell, Department of Physical Chemistry, at the University of Michigan.

AFFIDAVIT OF EDWARD C. HARDY

I am a resident of Mt. Pleasant, in the County of Isabella, State of Michigan, my address is 503 East Chippewa Street, and I am employed by Dowell Incorporated as station manager at Mt. Pleasant, Michigan.

On September 15, 1938, upon instructions from The Dow Chemical Company, Legal Department, I removed certain glass bottles containing samples of materials from the vault in the main office of The Dow Chemical Company at Midland, Michigan, and transported them to Ann Arbor, Michigan, where I delivered them to the office of Dr. Floyd E. Bartell, Department of Physical Chemistry, at the University of Michigan.

Affidavit of Floyd E. Bartell

AFFIDAVIT OF FLOYD E. BARTELL

I am a resident of Ann Arbor, in the County of Washtenaw, State of Michigan, my address is care of the University of Michigan, and I am Professor of Chemistry at the University of Michigan located at Ann Arbor, Michigan.

I was in Midland, Michigan, at the office of The Dow Chemical Company at various times within the last several years and there on the dates indicated received from the Legal Department of The Dow Chemical Company samples of various materials bearing the numbers as follows:

No. 5	August 23, 1939
No. 6	August 23, 1939
No. 8	August 8, 1938
No. 12	August 23, 1939
No. 15	August 23, 1939

Additionally I have received from various persons of The Dow Chemical Company other samples of materials bearing certain numbers which were delivered to me at my office at the University of Michigan at Ann Arbor, Michigan, by the persons and on the dates indicated:

No. 12-B, August 24, 1938, delivered by D. L. Conner.

No. 15, August 31, 1939, delivered by L. C. Chamberlain.

No. N-14-B, September 15, 1938, delivered by E. C. Hardy.

No. S-14-B, September 15, 1938, delivered by E. C. Hardy.

Additionally, on December 14, 1938, I received samples of material marked Samples Nos. N-17-B and S-17-B from The Dow Chemical Company which samples came to me by express.

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DR. FLOYD E. BARTELL,

a witness called by plaintiff, testified as follows:


DIRECT EXAMINATION

I am Professor of Chemistry at the University of Michigan, occupying the position since 1910. In this position I am responsible for the work of the department of general and physical chemistry, conduct classes in physical chemistry including colloid and surface chemistry, and direct the research of numerous graduate students. I have a Bachelor's Degree, a Master's Degree and the Degree of Doctor of Philosophy, the last two from the University of Michigan.

I have had numerous occasions to study patents and am familiar with the Grebe-Sanford patent 1,877,504, having studied it in connection with my work in this case. I understand the patent to relate to the treatment of deep wells, such as oil, gas, brine or water wells for the purpose of increasing their yield, particularly those in a mineral bearing stratum consisting of limestone or other calcareous formations.

The principal object of the invention is to counteract in some way effects which may have come about which have tended to decrease the yield or output of the wells. The patent points out in some cases the output may have decreased to such an extent that further operation has become unprofitable. The idea is to introduce into such wells a solution containing acid or consisting largely of an aqueous solution of hydrochloric acid, which will react with the formation, increasing the size of the openings or crevices.

The next point mentioned in the patent is that in carrying out the method an acid is employed, preferably hydrochloric acid, to which is added a small amount of a substance which is capable of inhibiting the attack of the acid



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upon metal surfaces, such as upon surfaces of iron or steel. No mention is made at that point as to why that is desirable but it is pointed out that it is desirable. Mention is made as to inhibiting agents used, a preferable one being an arsenic compound soluble in the acid solution, such as arsenic acid, arsenic trioxide or soluble arsenate. It is pointed out, also, other inhibitors may be used, such as cyanides, organic nitrogen bases such as aniline, phenylhydrazine, pyridine, quinoline, acridine and derivatives thereof, organic sulphur compounds, such as mercaptans, as well as various by-products of industrial processes. Then the patent goes on to mention that the strength of the aqueous hydrochloric acid solution which is preferable is between 5 and 20%—I should say the preferable concentration really between 10 and 15%, although other concentrations may be used.

Then the author of the patent goes on to mention how the acid may be added. The acid solution is preferably added in an amount calculated to fill the bore of the well to a depth not exceeding the thickness of the mineral bearing stratum, and points out to force the charge of acid out of the pump tube into the bore of the well against the head of the oil standing in the well it may be necessary to introduce pressure to force out the acid by pressure or other suitable means, as by a pump. After the acid has reacted with calcareous material and has practically ceased, it is suggested that the spent solution may be removed from the well by pumping or by bailing out. An example is given of the practical use of the method in the Central Michigan oil fields. I don't know that it is necessary to go over the amounts of materials used. It is suggested that 15% hydrochloric acid solution might be used with 2 gallons of arsenic acid, 4500 pounds total of the acid, and 2 gallons of arsenic calculated as As_2O_5 . It is suggested that this mixed solution can be charged into the oil well through the iron pipe tube; that this may be followed by a quantity of crude oil to force the acid out of the bottom of the tube into the well, and then after the acid has become exhausted may be

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pumped out and thereupon regular pumping of the oil may be resumed. In the case mentioned in the application in the Michigan field, it was stated that the production of the well treated was approximately doubled with one treatment.

Then the patent further states the method has been used repeatedly for the treatment of low yield or exhausted oil wells in territories, with resulting increase in output resulting from 75 to 200%, and that in some cases that the wells which have ceased to flow have been brought back to the resumption of the natural flow.

On page 1, line 43, it is pointed out—"As an illustration, a chemical method is described in United States Patent 556,669, according to which the flow of an oil well in a limestone formation is increased by treating with a quantity of an acid, such as hydrochloric acid."

The Court: Well, now, what new do they claim? What improvement do they claim they made over that? How do they claim they change? A. My understanding is that the main claim for improvement is the addition to the hydrochloric acid of some material which will inhibit the action of the acid.

The Court: There is no claim that the acid, for instance, in this well, would not have done just as good a job as if it had not gone into it— A. I do not believe so.

The Court: They do not claim any new useful result. They just claim to have avoided a misfortune. A. The useful result would be limited apparently to the equipment, rather than to the well itself.

The Court: As far as increasing the flow of the well, and all of that, they do not claim to have accomplished anything? A. I don't think so.

The Court: But simply to have avoided a misfortune? A. I think so. Inhibitors, such as are suggested here, as far as I know, would have no effect on the acid, in connection with its reaction upon limestone.

The Court: All right. In other words, it has absolutely,—the adding of this has no effect that we know anything about or claim anything about on the work which

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is desired to be done in treating the well? A. That is my understanding. But, it does have a specific function on the metal equipment used in connection with the well treatment.

By Mr. Owen:

Q. Would you say, Doctor, whether or not the presence of an inhibitor in the acid, which will prevent or restrict its reaction on the pipe and other well equipment, would have any bearing on the strength of the acid which goes into the formation? A. As I understand the question, the answer is "No." That is to say, the mere presence of the inhibitor in the acid would have no effect on the strength or work the acid would subsequently be able to do.

Q. Would an uninhibited acid which attacks the metal reach the formation in the full strength in which it was introduced into the well tubing? A. No, it would not. Some of the acid would be expended by reaction with the metal of the well tubing.

The Court: What fraction of one per cent do you think it would be diminished? Surely not more than one, not above; it would be a fraction of one per cent of your total acid as it went down into your well, wouldn't it? Don't you think it would be less than one per cent that would be diminished? A. Well, it would depend on the rate at which the acid were added and the amount added and the method of handling it in general. That would vary, of course, with treatments, depending on the amount of acid used in a specific treatment as well as the method in which it was used.

The Court: Which does it like better, iron or lime? A. It will react more rapidly, ordinarily, with lime.

By Mr. Owen:

Q. Have you tested and analyzed any samples of hydrochloric acid solutions for the Dow Chemical Company during the past two or three years, which you understood to have been some of the acid used by the defendant in this case, the Halliburton Oil Well Cementing Company, in treating wells in the Central Michigan fields? A. We have.

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Mr. Owen: I will state for Your Honor's information that some of the depositions which were offered in this case and were not read dealt with the obtaining of the samples from the oil wells and sealing and delivery to the vault of The Dow Chemical Company, and then there were affidavits signed by the men who delivered those samples from the Dow Chemical vault to Dr. Bartell and Dr. Bartell's affidavit that he had received them, and it was stipulated that if those witnesses were called they would so testify.

Mr. Lyon: That is correct.

The Court: I am satisfied as to the identity of the samples.

Mr. Owen: It was just to trace the samples from the Halliburton tanks to the laboratory of Dr. Bartell.

The Court: I am satisfied with that proof.

By Mr. Owen:

Q. Who, if anyone, assisted you in making the analyses of these samples? A. Dr. Paul H. Cardwell.

(Dr. Cardwell was present and also was sworn as a witness.)

Q. What has been Dr. Cardwell's education and training? A. He received the Bachelor's degree at Central State Teacher's College in 1935. He entered the graduate school of the University of Michigan in 1936, received the Master's degree about a year later, and then served as assistant in the department, Teaching Fellow, and obtained his Doctor's degree in June of the present year, 1941. He has specialized in chemistry during all of his graduate work.

Q. It is in evidence that samples of acid taken from defendant's truck tanks during its acid treatments of the Stella Wilcox well on August 5, 1938, of the Zahn well on August 19, 1938, and of the Crawford well on September 10, 1938, all in Ogemaw County, Michigan, were delivered to you; the Stella Wilcox samples being numbered 5, 6 and 8, the Zahn samples being numbered 12 and 12-B, and the Crawford samples, two in number, being numbered 15. Will you state whether or not you received such samples? A. I did receive such samples, with the same numbers as mentioned.

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Mr. Lyon: May it be understood that any testimony regarding these samples is subject to the objection heretofore made, without the necessity of further repeating that objection? That is the objection as to the fact that those wells were treated on the authority of and with the consent of the Dow Company.

The Court: Yes. I will overrule that objection, so you may have the benefit of having objected to the question, and I give you an exception to it all the way through.

By Mr. Owen:

Q. What, if any, instructions did you receive in connection with those samples? A. I was instructed to examine them, to determine whether they contained hydrochloric acid, and the approximate strength, if the acid proved to be hydrochloric acid, and to make corrosion studies to determine whether or not these samples of acid contained a material which served as an inhibitor, in so far as the corrosive effect against iron or steel was concerned. Each of these samples contained hydrochloric acid of approximately fifteen per cent concentration.

Mr. Lyon: I am not interested in that analysis. There is no question about the defendant using hydrochloric acid.

The Witness: We were requested to test the samples and determine their corrosive action on iron or steel, and naturally we expected to compare the action of these acids with acids which we knew to contain no inhibitor, and the test we were to make was for the purpose of determining whether or not these acids contained a substance which functioned as an inhibiting agent. And, so, to make the test that was requested to determine whether or not these samples contained material which functioned as an inhibiting agent, the thing we did was to obtain chemically pure hydrochloric acid, make up solutions of strength identical to that of each of the samples mentioned, and test them side by side, figuratively, to determine the corrosive action of the chemically pure acid in solution with that of the oil well sample solution and note their reactivity on the metal. Perhaps I should make a statement before starting in, which may save

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me embarrassment later. Naturally, the amount of samples we had was limited; otherwise we could have made, perhaps, elaborate tests. But we had, as I recall, not over about a liter of each of the samples. A liter is in the neighborhood of a quart. So we had to regulate our set of experiments accordingly.

In setting up the experiments we decided to use about 50 c.c. for each test, since it would be desirable to run a number of duplicate samples. That would fill perhaps a two-ounce bottle. The acid was placed in small wide-mouthed bottles. They were about 3 inches in height and an inch and a quarter by an inch and a quarter in width. The metal pieces used for testing were rectangular pieces $1'' \times \frac{7}{8}''$ by $\frac{1}{8}''$ thick. In the first series of tests which I will mention, these pieces were cut from strap iron. A small hole was drilled through the metal at one end near the middle or center so that the strip could be suspended in the liquid. The strip was suspended by means of a glass support so the acid would not react on it. In the first series of tests, the solutions were not agitated. The experiments were carried out at a temperature of 85 degrees Fahrenheit, and the time of the tests was 16 hours.

The Court: As I understand it, you had one of these containers with the acid that came from the defendants, and then one of acid that was not inhibited? A. That is right.

The Court: And you took the same length of time, and the experiments were made under identical conditions? A. Under identical conditions, treated in the same manner just as far as it was possible.

Mr. Lyon: There is just one bottle of defendant's acid in this, and one bottle of chemically pure acid, is that right? A. No, that represents a single test. Duplicates were always run of not less than five, or three at least, not less than three at least of each.

The metal strips were sawed from about an inch wide strap iron, and then were sand-blasted, for cleaning, and were not touched after the sand-blasting, that is, touched by hand, or in any way on the surface.

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By Mr. Owen:

Q. You did not give the strength of the samples of defendant's acid, can you give that? A. I can. The strength of sample 8, as indicated on my notes, was 14.8 per cent, that is the sample for the Stella Wilcox, 14.8. Sample 6 Stella Wilcox, 14.8.

The Court: They were taken out of the same tank, as I understand it.

Mr. Owen: That is right.

A. Of course, there might have been a slight variation if the sample bottle was dipped into the tank at different points, or stirred up the material after dipping. I don't say there was any reason why the samples should analyze exactly the same.

Mr. Lyon: Do I understand, Mr. Owen, the plaintiff took one two-gallon sample or took two one-gallon samples?

Mr. Owen: Two one-gallon samples.

By Mr. Owen:

Q. What was the strength of the other samples? A. The sample indicated as 12-B was 14.5 per cent, and the sample indicated as 12 also 14.5 per cent. From the Crawford well, we had two different samples which happened to carry the same number, 15. They were obtained by us at slightly different times. They both were of 15.2 per cent concentration.

The Court: That comes out the way we would expect. There isn't exact uniformity between wells.

Mr. Owen: That is right.

The Court: But as to samples from the same wells, complete uniformity. It so happens, as you point out, we wouldn't be greatly disturbed or surprised if there had been a little difference, but there wasn't any. A. That is right, Your Honor.

The Court: They had them pretty well mixed, in other words.

Mr. Owen: The truck had traveled, I think, 60 or 70 or 80 miles, and they probably were pretty thoroughly mixed.

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The Witness: By blank samples we refer to samples of the acid that we made up by using chemically pure acid with water, of the same acid strength as the particular tank sample. For the Stella Wilcox well we prepared but one blank, since all of the acid samples were of the same strength, namely, 14.8 per cent. That is true also of the Zahn well and the Crawford well. I have tabulated the results of our comparative corrosion tests made with the samples of defendant's treating acids and with these blanks which we prepared. I have such data in form indicated as table I.

Mr. Owen: I offer this table in evidence as Exhibit PX-154.

A. In this table I recorded the results obtained in corrosion tests, as described; namely, with metal strips of strap iron of approximately 1 inch by $\frac{7}{8}$ ths inch by $\frac{1}{8}$ th inch, with the solutions as indicated in the first column of the table. The experiments were all carried out at 85 degrees Fahrenheit, using 50 c.c. of the acid solutions. The tests were all carried for the same length of time, in this case 16 hours. The metals used are from two batches of strap iron, one marked Series B and the other Series D. It happened to be that those were from different pieces of strap iron. In the second column of the chart is represented the per cent of hydrochloric acid. In the third column is represented the initial weight of the metal strips. In the fourth column, the final weight, that is to say, the weight after the action of the acid upon the iron. In the fifth column is given the loss in weight. In the sixth column the per cent loss in weight. In the seventh column the calculated per cent reduction in corrosiveness. I will explain the meaning of that seventh column later.

As an example, in one series of tests with Sample 8, Stella Wilcox, a single experiment gave these data: The initial weight of the strip was 14.4300 grams. The weight after action of the acid indicated as final weight 14.1386. The loss in weight 0.2914 grams. Or the per cent loss in weight would be 2.02.

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Now, the average values, obtained by three sets of tests as indicated, gave as an initial weight 14.4308 grams. The final weight 14.1415 grams. The loss in weight 0.2893 grams. The average per cent loss in weight 2.01. And it would be noted that the average per cent loss in weight was practically the same as the per cent loss in weight of the single sample first mentioned.

In the second series of tests, using blank acid of the same strength as Sample 8, and referred to as "Blank 8 C. P. HCl.," the average initial weight in grams of three samples was 14.4287. The final weight in grams average was 13.8816. The average loss in weight of the three samples 0.5471 grams. Or a per cent loss in weight of 3.79.

I think perhaps the simplest way to represent what is meant by per cent reduction in corrosiveness, and how the figure 47 in the last column was obtained, would be to represent it in this way: It will be noted that the average per cent loss in weight of Sample 8 was 2.01, and the average per cent loss in weight of the corresponding blank was 3.79. Now that represents the ratio of per cent loss in weight. Now if one lets the loss in weight obtained with the chemically pure acid be represented by 100 per cent, one then would have the ratio of 2.01 is to 3.79 as x is to 100, and the x would represent then the relative corrosiveness of the sample acid. Now, in that case x would represent and be equal to 53. Or 2.01 is to 3.79 as 53 is to 100.

The Court: Well, is the 47 per cent of 3.79? A. The corrosiveness would be as 53 is to 100. The reduction in corrosiveness then would be 100 minus 53 or 47. The 47 would represent the reduction in corrosiveness of the sample acid as against the CP acid. Or, suppose we were to represent that diagrammatically. If one were to represent the amount of corrosion of the C. P. acid by a straight line and let that line represent 100 per cent, the corrosiveness of the sample acid would end out here at 53 and the reduction in corrosiveness would be represented by the value 47. So setting it up in that way it is fair to state that the reduction in corrosiveness was 47 per cent. The amount

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of corrosion would be dependent on the surface area, but it happens these small pieces were cut all to the same size and so had practically the same surface.

We followed the same procedure with respect to each one of those different samples as I have explained with respect to Sample No. 8. The sample indicated as 12-B from the Zahn well showed a reduction in corrosiveness over that of the CP acid of 48%. The corrosiveness was 52% that of the corrosiveness of the CP acid, or the reduction in corrosiveness was 48%. The Stella Wilcox sample No. 5 showed a reduction in corrosiveness over that of the CP acid of 42%. Stella Wilcox sample No. 6 showed a reduction in corrosiveness of 42%. The Zahn sample No. 12 showed a reduction in corrosiveness of 42%, and one of the Crawford samples No. 15 showed a reduction in corrosiveness of 69%, and the other one 71%. Approximately the same.

By Mr. Owen:

Q. Well, now, I understand that samples No. 8 and No. 5 and No. 6 came from the same well, the Stella Wilcox, and from the two-gallon sample of defendant's acid which was taken at that time. Will you explain, if you can, the difference in corrosiveness or reductions in corrosiveness which you have found for those different samples? A. Well, since the acid content of those samples is the same throughout, it must be that there is a slight variation in some other constituent present in the samples.

Q. Did you make any other tests with these same samples of defendant's acids and the corresponding blanks? A. Yes.

Mr. Lyon: I don't understand what the bottom figures are. Average 15 blank, and then there are 3 blank fifteens in there. What is the significance of those? A. Well, the average of 15, the figure indicated by that, would come over in the fifth column, which is 0.2454%. That means that the average of two samples 15 had a value of 0.2454% loss in weight.

Mr. Lyon: No. I was asking about 3 at the bottom,

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Dr. Bartell. I don't understand what blanks those were that were added together under that title Blank 15 CP. Then there is another one and another one. What 3 blanks were those? A. Oh, those were simply separate tests with the same concentration of acid but using different pieces of metal. You see in the column 3, the initial weight in grams is slightly different, indicating that separate tests were made, 3 distinct tests with that particular sample of acid.

Mr. Lyon: Well, can you explain to us again why the per cent loss in weight on those 3 blanks average 5.73, while the blanks up in series D seem to be around 3 and 3.5; or thereabouts? A. Would this be a fair question as to why the per cent loss in weight shown by the blanks 15 are higher than the per cent loss of weight shown by the earlier blanks?

Mr. Lyon: Yes, that is why I am trying—(Witness interposing) Well, if you use the question, I think a fair answer would be that probably the two series of metals used were of slightly different composition and had different rates of corrosion.

Mr. Lyon: They weren't cut out of the same metal? A. No. Series D was cut out from one strip of strap iron; Series B another. So the iron differed slightly.

By Mr. Owen:

Q. Now, I asked you if you made any similar tests with these acids using other materials, and I believe you stated that you did. Will you refer to those tests, and if you have any table showing them, will you produce that table? A. We have made similar tests with other materials, with metal strips cut from oil well pipes. We obtained oil well pipe from the National Supply Company, from the Oil Well Supply Company, and from the Atha Supply Company. We have data corresponding to the data given for the experiments made with strap iron, for metal strips of approximately the same size as those used of the strap iron material, but cut from oil well pipe.

The metal pieces were approximately, in the case of

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the National Supply Company pipe, one inch by $\frac{7}{8}$ ths by $\frac{3}{16}$ ths. The thickness of the pipe of the different companies was all practically the same, all practically $\frac{3}{16}$ ths, and the other dimensions were 1 by $\frac{7}{8}$ ths, the same. The same amount of solution, of the acid solution, was used as was used previously, namely, 50 c.c. The experiments were carried out at 85 degrees Fahrenheit, and the tests were again run for a period of 16 hours.

Mr. Owen: The table showing the results of those tests is offered as PX-155.

By Mr. Owen:

Q. Will you explain what this Exhibit PX-155 shows?

A. That shows the results obtained in corrosion tests, using the National Supply Company pipe material, with the different acid samples. We followed the same procedure as we did with the strips of strap iron which I have already explained. We prepared blanks of C. P. acid, of strengths corresponding to each of the oil well samples, and carried out the experiments in exactly the same manner.

PX-155 relates only to the tests made with the National Supply Company pipe. I also have tables showing the results of our tests with the other two pipe samples. The results obtained with the Oil Well Supply Company pipe material are shown in Table III.

Mr. Owen: That will be offered in evidence as PX-156.

The Court: Let me see about PX-155. This differs from the other only in that you used different materials for the acid to eat on? A. That is right, Your Honor. That is the only difference between this and PX-154. The pieces of metal were essentially the same size, but different kind or quality. And the acids were the same, and we took the same length of time, 16 hours, but it was different metal, oil well tubing instead of strap iron.

The Court: I can't compare the results, can I, on account of the shape? Wasn't that different? A. The shape was practically the same except the thickness was just a little different, because the thickness of the pipe was a little different than the thickness of the strap iron. The pipe was

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a little thicker. The strap iron was $\frac{1}{8}$ th of an inch thick, and the pipe about $\frac{3}{16}$ ths.

The Court: There wasn't as much difference in percentage? A. That is true.

The Court: And, how do I know but what that is all due to the difference in the shape? A. Well, I can very quickly, Your Honor, give you the relative ratios of those surfaces of the metals, if you wish, and they are so nearly the same that that would not quite account for the difference that occurs in the corrosiveness. The area, surface area as calculated for the surface of the strap iron strips was 14.58 square centimeters. For the National Supply Company pipe, 14.52 square centimeters. The area of the Oil Well Supply Company sample was 14.52 centimeters square, and the surface area of the remaining sample cut from the Atha pipe was 15.33 square centimeters. So, it will be noted there is not a great difference in the surface area altogether.

Mr. Lyon: Just so the record will be clear, Doctor, these samples on which these tests were made were immersed in the acid so that the metal strips or specimens were contacted with the acid on both sides of the metal, were they not? A. On all sides, yes. The area I am giving you represents the total area exposed on all sides.

Mr. Lyon: And were these other pieces of metal in Tables II and III, and similar tables, all sand-blasted before— A. (Interrupting): They were all treated in exactly the same way.

The activity of both the oil well sample acid, and the blank acid, the action was greater with the oil well pipe than with the strap iron.

Mr. Owen: Table IV, showing the results of tests with Atha Supply Company pipe is offered as PX-157.

By Mr. Owen:

Q. As I understand you, these results or these tests, the results of which are shown in your tables numbered I, II, III and IV, which are in evidence as PX-154, 155, 156 and 157, represent the results of similar tests with four different metals? A. That is right.

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Q. And the only difference in the tests was in the metal used? A. Yes, so far as we could control the experiments.

Q. Are you able to give the average reduction in corrosiveness in the tests made with strap iron as between chemically pure acid and the several samples obtained from the defendant's treating tanks? A. Yes, I think so. With the strap iron the average percentage reduction in corrosiveness of Samples 5, 6 and 8 from the Stella Wilcox well, gave a value of 44 as per cent reduction in corrosiveness. The average reduction in corrosiveness of all seven samples shown in PX-154 is 52 per cent.

The Court: That is the average of the samples taken from the wells? A. That is right, Your Honor. The reduction in corrosiveness was obtained for each of the seven samples and the average of those values gives a figure of 52, which means that the average of the reduction in corrosiveness of the 7 samples is 52%.

The Court: You took the average of those because they differed too, the CP acid experiments? A. Oh, they did.

The Court: You took an average on those? A. Yes, Your Honor. In each case, the sample obtained from the well, the acid sample was tested against a CP acid sample of the same strength.

The Court: But the CP acid of the same strength differs? Take right down in your table I, where you take the first line, blank A, so and so, you come over there. A. Yes, the blanks, the concentration of the CP acids, were changed to fit the corresponding acid which they were tested against.

The Court: But the loss in weight is a little bit different on those two. I have .0142 difference in one. That isn't very much.

Mr. Lyon: Maybe we could ask this question. I don't think it is out of order, if the witness can tell us, so that we will know something about what order of accuracy these measurements are believed to have. Within what percents or what decimal point are these results reproducible, do you know? A. Well, I think the set of three tests would

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come pretty close to giving us that answer. No two pieces of iron are going to be exactly the same, so that the results will not be identical, but in the first set of values, for example, with the sample 8, Stella Wilcox, the loss in weight of the very first sample was 0.2914 grams; of the second sample 0.2911 grams, which means in that case the two losses in weight checked to within three ten-thousandths of a gram, which is most surprising. But in the third series, the loss in weight was .2854, which is somewhat larger than the other two. So I think that that will indicate pretty well the type of variation to be expected with different samples of the same liquids, but with different samples of iron.

The Court: This question will probably show where I have missed something, or my ignorance, or something. I want you to show this so you can set me right. Now I am looking at Table I, Series D. Then take the very first line, sample 8 Stella Wilcox. Now, that is followed by 3 there, and as I understand it, so far as you know, those three samples are out of the very same liquid. You only ran it to check your test, for safety in your test rather than to find out whether it was different, because you started in with the knowledge that those samples of acid were exactly alike, as I understand. A. As a matter of fact, Your Honor, we took out of the same bottle the material which we diluted and we used identical solution for the three different tests.

The Court: As I understand the running of those three tests was to avoid making a mistake, and they did come out near enough alike so you were satisfied you hadn't made a mistake, isn't that the right theory? A. Yes.

The Court: In other words, the only thing there was that could be any different was in the iron, and probably in cutting out the iron there would be a little difference there? A. Well, yes, Your Honor, but not a difference in size, but probably the composition of the two pieces of iron.

The Court: Even though they were cut out of the same strip? A. Even though they were cut out of the same strip there would be some little difference.

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The Court: I say, if there is any difference, it was not in the acid, but it was in the sample that you were treating, is that right? A. That is right.

The Court: The same thing applies when we come down to the blanks that you have? A. That is right.

Q. Your acid was just alike? A. Exactly the same.

Q. As I say, you got three pieces of iron as nearly alike as you could get them? A. That is right.

Q. But any difference there was there in that result probably comes from a difference in the iron, is that right? A. That is right.

The Court: Now do I understand you to say that you have compared for certain figures, taking the initial weight and the final weight, and loss in weight, and percentage of loss in weight and so forth—do I understand that you have compared a certain one in that first group with a certain one in the second group? A. No, Your Honor. We have taken the average of all three in the first group and compared them with the average of the second group.

The Court: You made no comparison of each one? A. No comparison of each one. We simply compared the average of those in the first group with those in the second group.

The Court: Because there was no reason for picking out the first one here and the first one there and comparing them, is that right? A. No, there would be no point in picking those out and comparing them in that way.

The Court: All right. I have followed you.

By Mr. Owen:

Q. Turning now to PX-155, which is your Table II, can you state the average reduction in corrosiveness of all of the tests shown on that sheet, comparing the tests of the defendant's acids with those of the C. P. acid? A. Calculating the per cent reduction in corrosiveness for each of the sets of defendant's acid against the blank and then taking the average of each of those values gives us for the seven samples an average value of 30 per cent. And table III, by similar calculation, gives an average for the seven

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samples of 38 per cent. Table IV shows for similar calculations a value of 48 per cent. Now, if you want to go further than that and take an average of all those averages you have a value of 42 per cent.

The Court: What do you do, just add them together and divide by 4? A. That is right, Your Honor.

The Court: Have you got the same number of experiments on each sheet? A. Just about.

The Court: If you haven't, you wouldn't be just right to do it that way? A. No.

By Mr. Owen:

Q. Doctor, I had on my preliminary chart a figure of 49 per cent for the average reduction in corrosiveness in connection with your Table IV and you gave it as 48 per cent. I have just had Mr. Cardwell check it, and he informs me that 49 per cent is correct. Would you mind checking it to be sure? A. I am not surprised, because I made a hurried check of that in pencil a short time ago.

The Court: What would you do, add them together and divide by 10?

Mr. Owen: Yes.

The Court: We ought to be able to do that all right. We might make a mistake about the other. A. Well, the difference is apparently that I took an average of seven samples, and perhaps the average just calculated was for the ten samples.

Mr. Allen Owen: While there are ten figures appearing in this last column, Your Honor, the 4th, 7th and 10th figures are averages of the ones immediately above them, so it would not be fair to add all of them. You should add figures Nos. 1, 2, 3, 4, 6, 8 and 9 and divide by 7 in order to get the proper average percentage reduction in corrosiveness.

The Court: I think we will all agree to that.

The Court: And you have got to treat averages with great care. We will suppose that we average the percentage of colored people in Bay City with the percentage of colored people in Detroit, add the two together and di-

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vide by two. You get a very bad result. One is so great that Bay City doesn't cut much figure, yet you are giving it an equal ranking. Maybe that does not enter in here, but I am suspicious that it does somewhere. Do you still stick to your figures? A. Well, Your Honor, I perhaps was inclined to leave the number low and not use the highest figure possible. It is between 48 and 49. It is a little closer to 49 than 48, so perhaps we should call it 49. I think we would be justified in calling it 49.

The Court: Does that mean in English and in figures that this that the Dow was using on that first group right there, we will say the amount of corrosiveness was 47 per cent of what the acid without any inhibitor would be? A. Yes, Your Honor. Or referring to the graph on the chart the C. P. acid gave a certain corrosiveness.

The Court: Well, but which is the amount it ate up? A. The amount it ate up, yes, Your Honor. And with the acid sample referred to, Sample 8, the corrosiveness was really 53 per cent of that of the C.P. acid. Or the reduction in corrosiveness over the C.P. acid was this value of 47 per cent.

The Court: Well, is this your contention as a result of that, that no matter what the shape is, no matter what the size is, if you use those two kinds of acids, this kind which the defendant uses will eat 47 per cent as much as the pure acid? A. Not 47 per cent as much. It will eat 47 per cent less of the iron than will the C.P. acid.

The Court: It reduces it 47. A. That is right.

The Court: To put it the other way, it will eat 53 per cent as much. A. Yes, Your Honor, with that particular iron.

The Court: No matter what the shape is? No matter what the weight is? But it has got to be left sixteen hours. A. I believe that to be true. Provided the ratio of the surface area to the amount of solution were the same.

The Court: I want it to happen the same in each case, that is, exactly the same size, of this kind of iron that you have, exactly that kind of iron, but I thought if you were

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right in your argument, that no matter what the shape was, no matter what the quantity was, that if you put the same quantity and the same kind into each, the same shape in each, and left them there for 16 hours, of this kind of iron, mind you, that it was your conclusion that the defedant's acid would eat 53 times as much as the pure acid? A. Your Honor, unfortunately that does not happen to be quite the fact, as we have discovered.

The Court: I thought you were claiming that much for it. Now, you do not claim that much for it? A. I cannot claim quite that much for it.

The Court: Well, all right. What is it that you do not claim to be the fact? A. I must face this fact, that by altering the area exposed as compared to the volume of the acid medium, that that fact, the relation of the area to the volume of acid medium will make a difference. That is difficult to see why at this point, but we will have to face that fact.

The Court: A different iron might make a difference? A. Yes.

The Court: But here you have got two different kinds of strength? A. Yes.

The Court: Say, two men of different strength, one might be able to do a lot more than the other one could do, one might take quite a lot on, and the other take a little, but we can figure out their percentages as to their strength; on other kinds of work you can figure out very accurately the percentage of strength? A. Yes.

The Court: I knew that you did not make any claim that with different kinds of iron your result would be uniform? A. I have found, Your Honor, that I cannot even make the claim that you suggest, at first I thought I might be able to.

The Court: I am glad to know it, because I thought— A. And that will come out later.

The Court: Then what good do these percentages? What do they prove? A. They will show, with the experiment run under these conditions, that the C. P. acid is

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more active than the sample acids. Now, if I had been fortunate enough, or wise enough to have selected different conditions in the first part of my experiments, I might have obtained results that would have been even more outstanding. I feel that the results that I am presenting to you at this time represent about the minimum of differences as it has worked out, but I did not know it when I ran these experiments.

The Court: Does whether it was under pressure or not make any difference? A. It might make some difference.

Mr. Lyon: What about temperature? A. It might make some difference.

Mr. Lyon: It does, doesn't it? A. I would expect it to. Some difference.

The Court: You mean the ratio would be different? A. Possibly. Yes, the difference in the ratio would be different.

The Court: There are some things we know. We have different kinds of iron in these two here and you have proven with a different kind of iron the ratio between the two acids varies. A. It varies, yes, it does. But in every case tested with all these different samples, the acid well samples showed less reactivity than the samples of the CP acid. That much we certainly have shown.

The Court: Then all this simply has to do with inhibition? A. Inhibition, yes.

By Mr. Owen:

Q. It is in evidence that there were delivered to you samples of hydrochloric acid taken from the wooden storage tanks of the Halliburton Oil Well Cementing Company at Mt. Pleasant. Those samples were marked N14-B, S14-B, N17-B, S17-B. Do you recall having received those samples? A. Yes, we received those samples, and I might mention that in all our records the samples marked N17-B and S17-B will be referred to as S20-B and N20-B. When the samples were delivered, as I recall, I was requested by Mr. Conner to use that notation and for the moment I don't recall why.

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Mr. Owen: That explanation is in the depositions that have been filed, Your Honor. Mr. Conner explained that when this sample was taken, the N17B and the S17B—that means the North and South storage tanks of the Halliburton Company at Mt. Pleasant—he marked them with the 17 N and S series, and when he later examined his list of samples he found that he already had a 17. So he requested Dr. Bartell to change the markings on these samples to N20B and S20B, but Dr. Bartell states that he did not change them on the samples themselves but that in referring to them in his testimony he will use the 20 figure instead of the 17.

Mr. Lyon: Before we start in with any tests on commercial acid, I want to raise a question regarding the proofs, because tests on commercial acid, as compared with the well acid, would not have any significance here. It would be necessary that the well acid and the commercial acid correspond to each other; in other words, that the well acid be that commercial acid after it has been in the tank and been acted on by the lead plate and the current.

We are not satisfied with the proof in this case, and want to raise an objection, that the commercial acid that they are relying on here is the commercial acid that was used in wells on which they have the samples from the well acid.

I would like to call Your Honor's attention to this fact, that the Stella Wilcox well, which the witness has samples of well acid, was treated on August 5, 1938; the Zahn well was treated on August 19, 1938; and the Crawford well was treated on September 10, 1938, as shown by the records, PX-18.

The testimony as to when the sample of commercial acid was taken from the storage tanks in Mt. Pleasant is in the depositions which were received here, but not read. The samples were taken by two of the plaintiff's employees, and the first one is a Mr. Forsman, who in his deposition states the samples were taken on the 18th of August and he says on page 113, "We immediately identified the sam-

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ples as to which tank they were obtained from, and they were delivered to the Dow Chemical Company at Midland, Michigan, to Don Conner."

The other witness who assisted in taking the samples was the witness Day, who testifies at page 106 of his deposition as follows: "Q. Well, is it your testimony whatever samples you took from these tanks you brought over here, delivered them to me, Mr. Conner? A. Yes, sir."

"Q. When you delivered these samples over to Midland to Mr. Conner, was Warner Forsman with you or not? A. Yes, sir, both times."

Mr. Conner: If Your Honor please, that refers to samples taken on two different occasions, August 18th and December 6th.

Mr. Lyon: And Mr. Conner on page 134 of his deposition states:

"I requested of Mr. Day and Mr. Forsman some time in August, they obtain samples from the wooden storage tanks of Halliburton which I was told had acid in them, located on North Franklin Street in Mt. Pleasant, Michigan, on August 18th. I marked that date very clearly because it was the day before the Zahn well was treated, I think. On August 19th Day and Forsman brought to me in the Midland office of the Dow Chemical Company, two bottles containing a liquid which they said was hydrochloric acid, each bottle had attached to it a sticker."

Mr. Conner, as I understand it, admits he was in error on that, because Mr. Babcock has showed him that he was in Oklahoma taking depositions at that time, and there is some mistake here, but the samples were taken some time by the light of the moon, and the Halliburton Company has no way of checking. But, obviously, it seems to me they were not the samples of the acid which was taken out of those tanks and taken out to the wells and used in the treatment of the wells, and it would become very significant in this case, I think, whether there is any,—in connection with any comparisons of the condition of the acid at the well and as it was in the storage tanks, whether we are comparing

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the right acids, and there seems to be some difficulty here, at least one of these wells treated on August 5th, and obviously that is a different acid from the one they are supposed to have obtained samples of the commercial acid, and another one on September 10th, which is obviously a different one, and the only one could be August 19th, and as to that, why, there is this discrepancy in the testimony, which, I think, needs some explanation before we accept it and go into a lot of proofs as to an exact comparison here which they are going to base an argument. If the samples are not correct, why, we shouldn't start with those proofs.

Mr. Owen: In answer to the statement made by counsel, I will say that there was a discrepancy in the testimony regarding the date at which one of these storage samples was delivered to the Dow Chemical Company and as to the person to whom it was delivered. Altogether, I think Mr. Conner or the witnesses secured some 12 or 15 samples and most of them were delivered to Mr. Conner, at least a good many of them were, and when he testified regarding the delivery of this particular sample he was in error and he admitted it later, and if there is any doubt about the genuineness of these samples, we will clear it up, Your Honor.

The Court: Well, I will treat that as an objection so you can save your record, and I will overrule it. That gives you your exception. But I will hear this proof. I will see. Have you made any experiment with the commercial hydrochloric acid? A. We have, Your Honor.

The Court: So you have got those figures, too? A. Yes, we have.

The Court: Well, wouldn't that help some?

Mr. Lyon: Well, the trouble is, if they are going to compare it with the acid at the well, it should be the commercial acid that was taken out to the well.

The Court: Well, this won't harm us.

Mr. Lyon: It won't hurt us.

The Court: But they say they have got the commercial acid, now.

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Mr. Lyon: Well, commercial acid differs, lots of hydrochloric acid differs, as we expect to show, as much as any figures that they are relying on in this case.

The Court: Well, I noticed that the differences weren't an awful lot here, but chemistry deals with pretty small things.

Mr. Owen: I am satisfied we can meet that criticism, Your Honor.

By Mr. Owen:

Q. When you gave the average of reduction in corrosiveness of all of the defendant's acids on your Tables I, II, III and IV (PX-154 to 157), objection was made that they were averages of averages, and without asking you to do it now, I will ask you to make up a new average and be prepared to state what that is tomorrow, basing your average on each individual test and eliminating the averages which are shown in the last column of your several tables.

Q. Now, referring to the samples of defendant's storage acid which were marked N14B, S14B, N17B and S17B, which you received, it being understood that you will use the number N20B and S20B instead of N17B and S17B, will you state whether you made corrosion tests of those storage samples? A. We did make corrosion tests with those storage samples.

The witness produced two tables marked VII and VIII which were offered and received as PX-158 and PX-159.

The Witness: Table PX-158 shows the results of tests with metal strips of strap iron of the same size as used in the first experiments previously described with solutions which were not agitated, and the experiments were carried out at a temperature of 85 degrees Fahrenheit as the previous ones, the volume of the acid solution used being 50 c.c. The time of the test was 16 hours. In other words, all factors relating to the test were essentially the same as in the previous experiments, other than that of the acid samples used. The acid samples referred to as N14B, S14B, N20B and S20B were found to be of concentrated hydrochloric acid of approximately thirty per cent concentration.

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The Court: Well, now what about the Wilcox? I have three on that. Now, Table II is the same?

Mr. Owen: Yes, Your Honor. That information applies to all exhibits.

The Court: And Table III is the same?

Mr. Owen (Interposing): As Table IV.

The Court: And so are II and IV?

Mr. Owen: Yes.

The Court: Where do I get that first sample N14B? Where was that from?

Mr. Owen: That was from the North storage tank of the defendant at Mt. Pleasant, and it was taken on August 18, 1938.

The Court: The day before the sample was taken from the Zahn well.

Mr. Lyon: That is the date I raise my objection to. Witnesses say they gave this sample to Mr. Conner while he was here. On that date Mr. Conner was taking depositions in Oklahoma.

The Court: When did you get this sample S14B?

Mr. Owen: Same as N14B, same dates and facts apply. The N stands for the North Storage tank, and the S for the South Storage tank. They have two wooden storage tanks at Mt. Pleasant.

By Mr. Owen:

Q. Now, will you explain what the data on PX-158 represents? A. I might mention that the acid samples from the storage tanks were of slightly different concentrations. The N14B originally as received was 28.5 hydrochloric acid; and the concentration of the sample labeled S14B was 29.3% hydrochloric acid; N20B was 30.3% and S20B 30.7%. I mention that to show that the acids were of slightly different strengths.

The Court: I don't understand why you didn't use them just as you found them. A. Had I done that, the strength would not have been comparable at all to the strength of the acid received as truck sample acid, which was about 15%, about half this strength.

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The Court: That storage tank, in there it is not ready for use then? A. No.

The Court: It is going to be diluted or changed by them? A. It apparently does have to be, yes.

The Court: You changed it to get it as near as you could to the way you thought they would use it? A. Yes, I changed it.

The Court: You are showing there wasn't any inhibitor in this?

Mr. Owen: Very little.

The Court: Let me ask you, Doctor, there is a difference between this chemically pure and commercial hydrochloric? A. There is some difference, yes.

The Court: Is there some, in this commercial is there some inhibitor in that? A. There are materials that inhibit slightly.

The Court: The way they sell it? A. The way they sell it, that is true.

The Court: Do you claim they have a patent so nobody can buy any more hydrochloric acid?

Mr. Owen: Oh, no, we don't complain of their using it in the strength in which they purchase it, and with the inhibiting power that it has.

The Court: All right.

The Witness: This storage tank acid of the strength mentioned was diluted to 14.5 per cent, which was the strength of the acid samples 12 and 12B taken from the Zahn well.

Mr. Lyon: May I ask if the dilutions that are referred to on these tables PX-158 and 159 consisted of nothing but the addition of water to the commercial,—or to the so-called commercial acid taken from the storage tanks? A. That is right. Nothing else was put in except pure water, and a blank of C.P. acid of the same strength was prepared,—“C.P.” meaning “chemically pure.” For example N14B the initial weight of the metal strip used was 14.5279 grams. The final weight was 14.0619 grams,—loss in weight 0.660 grams, per cent loss 3.21. And, for the same S14B diluted

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the same way, the per cent loss in weight of its metal strip was 3.29. For the corresponding tests made with the chemically pure acid of the same strength the per cent loss in weight was 3.46, which means that the sample N14B was 92.8 per cent as corrosive as the C.P. acid, or the reduction in corrosiveness was 7.2 per cent; while the sample S14B showed a corrosiveness which was 95 per cent as great as that of the C. P. acid—95.1 per cent, as a matter of fact, and the reduction in corrosiveness was 4.9 per cent.

The other samples N20B and S20B were diluted to an acid strength of approximately 15 per cent. It happened to be 15.1, which is the per cent concentration of many of the solutions we have used for comparison. The per cent loss in weight of the sample tested with the N20B diluted solution was 3.23 per cent, and the loss in weight of the metal sample treated with S20B was 3.36 per cent, and that of the sample treated with the blank of the same strength as the N20B and S20B was 3.64 per cent, which means that the reduction in corrosiveness of the sample N20B was 11.3 per cent; it was 88.7 per cent as corrosive as the C.P. acid, or showed a reduction in corrosiveness of 11.3 per cent. And the sample S20B showed a corrosive effect 92.3 per cent that of the C.P. acid or showed a reduction in corrosiveness of 7.7 per cent.

Mr. Lyon: Is that the same blank that you have at that point in PX-158? A. It would be the same kind of acid, yes.

Mr. Lyon: I call your attention to the fact that there are three values in per cent loss in weight for that blank, and—on both PX-154 and 158 and the individual values are identically the same, as well as the averages. Doesn't that indicate that they are the same? A. If that is true. Well, in other words, it was the same test. I, hurriedly in looking at these figures, did not happen to catch the corresponding values. The blank 14.5—(after examining documents); Yes, they were the same test.

The Witness: The blank of diluted N14B and S14B, using the C.P. HCl in PX-158 means that I took C.P. hydro-

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chloric acid and diluted it to the 14.5 strength, and it so happened that I had already prepared such a blank which appears on PX-154 in the fourth series of tests, which read "Blank 12-B (C. P. HCl)," and I used that blank and the tests with that blank in computing or making up the table PX-158. The same blank acid was used in testing against Sample 12B as was used in testing against Sample N14B and S14B, and the solutions were all made up to the same acid strength.

The Court: Doctor, let me call this observation to your attention and see whether I am correct in my interpretation, and, if I am, whether it means anything at all. As I interpret your figures in PX-158, by looking at your loss in weight in grams column and then over cross-wise I am going to compare sample S14B diluted to 14.5 with the second one in the blanks, which is the blank diluted—I don't know if I do understand. I understood your blank to be your chemically pure hydrochloric acid. A. That is right, Your Honor.

The Court: Well, it doesn't matter which one I take, and I am taking the one to make the most trouble for you, which is the second one there. A. All right.

The Court: Now, that is diluted to the same 14.5. Now, I compare over in this loss in weight, in grams, the two, and I gather there that the only difference is .0091. A. Yes; that is correct.

The Court: Well, that is mighty little, isn't it? A. It is.

The Court: Now, I go right down to the 4th and 5th in the column, which are supposed to be identically alike, as near as we can get them, and I find a difference of .0512. In other words, I have got more than five times as much difference between your blank samples tested as I have got between one of the defendant's tests and your blank. A. Yes, sir, Your Honor, but this—

The Court: Suppose I was looking here to find out how much this defendant's dope was inhibited, and to determine that it would be perfectly fair, wouldn't it, for one

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comparison, to go over to column 5, the loss in weight in grams, and take the second figure in that column and compare it with the fourth. Why wouldn't that be fair to see how much they had inhibited it?

Mr. Owen: Well, I think that in tests of this kind, Your Honor, it is impossible to have them exactly accurate, and that is the reason, there is a necessary variation.

The Court: But I say, if I was going to only run one test on each, that might be the one that would have been run.

Mr. Owen: Yes.

The Court: I understand you ran more for the purpose of getting the average.

Mr. Owen: Surely.

The Court: And checking yourself. But I am taking only one of those, and I am taking the lowest one and their highest one for the purpose, as I said, to trouble the doctor and make it just as tough as I could for him, you see.

Mr. Owen: If we had done that, we could have made a much better picture.

The Court: Yes, you could have. But I am taking the worst picture you can. I mean, maybe I studied it longer, I suppose, but there is one comparison, that all they would have inhibited it would have been .0091 grams.

The Court: In other words, if you had found the difference between Dow's and yours—

Witness (interrupting): Your Honor, may I remark that I don't believe the contention is that inhibitor has been put in this acid; that if they do not check, why it is just because there happens to be something in the acid that would cause them to be that different.

The Court: If you carried out into your seventh column (of PX-158) the difference between the fourth set of figures and the fifth, what will you get to put in the seventh column? 3.38, one is base, and one is something else—3.60, and what do we get for the seventh column?

(Witness made calculations, slide rule and mathematical)

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A. For that particular combination requested and double checked, that would be about 6.1%.

The Court: Well, now, in other words, that means that if we were making this test and the one in the fourth place has been the defendant's, it isn't—it's one of your blanks, chemically pure—but if that had been one of the defendant's and the one in the fifth place had been run just as it was, we could argue from it that there was 6.1%—six and one-tenth per cent inhibitor in it. A. It could be argued that way.

The Court: That shows the argument that could be made and how careful we have to be here. We know there wasn't any inhibitor in it. We know your two acids were just alike. A. That shows why we have to run a number of tests.

The Court: And I don't know how many we would have to run. We are satisfied those two are absolutely chemically pure, each of them 14.5% hydrochloric acid, and we run them, and there is 6.1% difference in their corrosive action. Now, there isn't, as a matter of fact, any difference at all. A. Shouldn't be.

The Court: And the difference all comes by the difference in that iron in some way. A. That is true.

The Witness: I have pointed out that based upon the tests in PX-158 the sample N14B showed a reduction in corrosiveness of 7.2 per cent; S14B of 4.19 per cent; N20B of 11.3 per cent, and S20B, of 7.7 per cent.

PX-159 shows essentially the same type of results for the same type of tests as are shown in PX-158, the difference being that instead of using the strap iron as the iron pieces, strips were cut from National Supply Company's pipe of the size indicated, 1 by $\frac{7}{8}$ ths by $\frac{3}{16}$ ths, and the experiments were run exactly as were the experiments with the strap iron. For acid in these tests we had the samples N14B, S14B, N20B and S20B, which we have just discussed, together with the blanks corresponding to these diluted acid samples. In other words, the concentrations of the acids were exactly the same as the concentrations used in PX-158.

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This is the National Supply pipe, and that is shown on Table II, PX-155. Referring to Sample 12B of Table II, the strength of the acid used there was 14.5, the same as we used in the tests for Table VIII.

The Court: But, over in Table II you had 14.8. Then you got down to the bottom and it says 15.1, and 15.2. You had a stronger solution of acid in Table II than you did in Table VIII. A. In some instances we did, slightly stronger acid, because the strength of the acid in the truck samples was a little greater for the samples taken from Stella Wilcox than from the Zahn well.

Mr. Owen: I think, Your Honor, you are overlooking the fact that the strength of the blanks was the same as the strength of the defendant's samples which were tested, so that those are the two that are compared in this Table II. You see where the strength of the Crawford acid was 15.2, the strength of the blank was also 15.2.

The Court: But, why was the loss in weight? When I am talking about loss in weight by defendant's acid and the loss in weight by chemically pure acid, I am not comparing one with the other. I was here considering loss in weight one with the other. Now, the size would have something to do with that? A. The loss in weight is not great; the sample N14B, 2.34 per cent, while with the blank, 2.53 per cent.

Mr. Owen: I think if Your Honor will keep this in mind it may help to understand these tables, that in every instance the comparison is made between a C. P. blank of the same strength as the defendant's acid which is being compared with it, so that you cannot say that that is not a fair comparison.

The Court: Do they say they have any of this lead metal electrical current in the storage tank?

Mr. Owen: No. That is a wooden tank.

By Mr. Owen:

Q. Now, did you also compare the storage, the defendant's storage tank samples, Nos. 14 and 20, with samples of commercial hydrochloric acids to see how their

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corrosiveness compared? A. We did. We obtained commercial acids by purchasing directly from the different companies, ourselves. Lots of acid from the Detroit Chemical Works, from DuPont, from the General Chemical Company, from the Pennsylvania Salt Manufacturing Company, and from the Southern Acid & Sulphur Company.

Q. Have you prepared a table showing the results of those tests? A. I have for my own notes. I have no other table prepared. The tests were made with each of these acids diluted to a strength of 15.1 per cent hydrochloric acid. The metal used was from strap iron of the same lot as Series A previously referred to. Tests were made in vessels of the same size and the same size strips were suspended in 50 c.c. of acid as before, for sixteen hours at 85 degrees Fahrenheit, and in containers of the same size and shape. And the results obtained expressed in the same units that I have been expressing the other values in terms of reduction in corrosiveness.

The Court: You have got the other figures that lead up to those, so that if they want to see them they can, I suppose. A. I can get any other figures leading up to those, yes. I have them with me in town.

For strap iron, first, I will give the results with Detroit Chemical Works acid. That acid compared to the same strength of C. P. hydrochloric acid showed a reduction in corrosiveness of 15.0 per cent compared with C. P. acid. The DuPont acid with the strap iron, 3.7 per cent. The acid from the General Chemical Company 1.6; The Pennsylvania Salt Manufacturing Company, 0.5 and the Southern Acid & Sulphur Company acid 0.3. In other words, that showed practically the reactivity of the same order of magnitude as the C. P. acids. Now, the average reduction in corrosiveness, taking the average of those five values, would be 4.2, or the average corrosiveness was approximately 96 per cent that of the C. P. acid.

The Court: Well, there you go. As between the Detroit Chemical Works and Southern Acid & Sulphur Company, The Detroit Chemical has got fifty times as much as

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the other of that inhibitor in it. A. It has relatively that much more inhibiting action, that is true.

The Court: And if anybody could step up from the other fifty times, they would have too much. Like the fellow who was asked if his brother-in-law was fifty per cent dependent on him, and he says a hundred and ten per cent. A. I have corresponding results with other metal strips, if they are wished.

The Court: That would be interesting. Now, this is all in the strap iron where we have such wide variances, except in the acid? A. Yes.

By Mr. Owen: You might as well give them, then, while you are on the subject? A. I thought it might be of interest to compare these results with those of the National Supply Company material, since we have already done that with the other series of acids. Using the small metal strips, of the same size as I have previously described, and using the National Supply Company pipe and the same acids as used with the strap iron tests, diluted to 15.1 per cent,—

The Court: Oh, you go right on down through, only with another kind of iron? A. With another kind of iron,—

The Court: What is the next kind of iron? A. The National Supply Company's pipe. I am taking the acids in the same order. The Detroit Chemical Works acid, a value of 12.2. DuPont, a value of 6.1. General Chemical Company, 5.4. Pennsylvania Salt Manufacturing Company, 0.7. Southern Acid and Sulphur Company, 0.7. The average of those values is 5.0.

The Court: Here is what surprises me now. The strap iron, the only difference between the strap iron and the National Supply Company pipe, when you use the Detroit Chemical, is just a difference of between 15 and 12.2, which is only 20 per cent.

Mr. Lyon: But it goes down.

The Court: And I come on down here to the next one, and I use the National Supply Company iron with DuPont, and here I get twice as much as I do when I use the other.

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I just cannot get it through my head. It does not seem to work. A. Of course, in the latter case it is twice as much, the matter of three units only, 3 per cent out of 100 per cent.

The Court: In one it is twice as much, when I use the National Supply I get twice as much depletion with that one kind of acid, and with the Detroit I get 80 per cent as much. A. That is true.

The Court: I would think at least they would run the same way. A. It leaves considerable room for speculation. It just might be, of course, the inhibitor in the two cases are not the same, and it doesn't function in exactly the same way with the two types of iron. That would be one possible explanation. The impurities in the acid may be different.

The Court: But I don't get much satisfaction in taking an average on a thing that works that way. A. The average in that case is probably not as significant as the other type of averages we have taken of the average of a series of tests. That is significant. Here we have involved another factor—the fact that the composition of these acids, so far as impurities are concerned, are unknown to us. They may not be the same.

The Court: Well, let's get some more irons in here and see where we come out. You have some more. How many have you got there? A. Two.

The Court: All right. I think I will go for them. A. And they leave greater room for speculation.

The Court: And what are the other two? A. The third iron is from the Oil Well Supply Company's pipe and the fourth one from the Atha Supply Company's pipe. Oil Well Supply Company's pipe with the Detroit Chemical Works acid, the first one mentioned previously, 1.3; DuPont 3.5; General Chemical Company 0.2; Pennsylvania Salt Manufacturing Company 0.6; Southern Acid and Sulphur Company 0.2. Those results admittedly are quite different from the other results, With the Atha, Detroit Chemical Works acid 18.4; DuPont 12.0; General Chemical

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Company 9.1; Pennsylvania Salt Manufacturing Company 3.5; Southern Acid and Sulphur Company, 9.4, showing distinctly that the different metals react quite differently with the constituents of the different acids.

The Court: I thought I could get down to the bottom there. When you came to the last one it jumps up 9.4. A. We simply took them as we found them.

The Court: If you could work something out of that—

Mr. Owen: I think Your Honor will find that these reductions in corrosiveness with these commercial acids with the exception of this one Detroit sample (and what is in that sample we don't know) but with that exception the reduction in corrosiveness as compared with the chemically pure acids seemed to run along in what the scientists call the same order of magnitude. They are not exactly the same but none of them is high enough to be any great amount of help in an oil well tubing.

Mr. Lyon: I understand that the plaintiff wouldn't charge infringement if any of these acids that have been referred to by the witness were employed as regular commercial hydrochloric acid with no addition of any other inhibitor. That is, DuPont acid or any of the ones the witness has referred to, is that correct?

Mr. Owen: I wouldn't say that, no.

The Court: You depend an awful lot on what you made your fight on.

Mr. Lyon: A fellow would have a hard time knowing on what he infringed.

Mr. Owen: I would say in answer to the inquiry that if the defendant or any other company which is acidizing oil wells for the purpose of increasing their production learned of a certain acid which contained impurities which were of a high order of magnitude and he selected that acid specifically for the purpose of getting the benefit of the Grebe-Sanford invention, I would say he probably would be held, or should be held, as an infringer.

Mr. Lyon: But if he did the same thing, used the same acid, he wouldn't be an infringer?

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Mr. Owen: Well, that is a moot question. I don't think it is involved here, and I don't think I am required to speculate on what we might do under those conditions, but what we are complaining about here is something that this defendant has done deliberately.

The Court: Well, it would take 47 times difference if they were going to use,—what is that, Southern, is that, acid? A. Southern Acid & Sulphur Company.

The Court: If they are going to use Southern Acid & Sulphur Company acid it would take 47 times difference whether you bought your pipe of the oil WXC, whatever that is,—if one digs into it, you have .2, and the other 9.4. If I am right $1/47$ times as much as the other. So, there is as much as you got in your figures difference than the kind of pipe they used with regular commercial acid.

Mr. Owen: That is true.

The Court: That is as much inhibition as you are suing them for.

Mr. Conner: No, it is not.

The Court: 47. That is what you claim here, 47.

Mr. Owen: No. We are showing that they are doing something to their acid that substantially increases its inhibitive power.

The Court: 47 per cent.

Mr. Owen: No. We don't say that they add 47 per cent of inhibition or of inhibitor to their acid, but we say that when their acids are delivered at the oil well and are used to acidize that well, that they are substantially inhibited within the scope of the Grebe-Sanford patent, and that that inhibition is due to something which they have done deliberately, and which has occurred between the time they placed their acid in their truck tanks and the time they delivered it from the truck tanks into the well.

Now, the question for Your Honor to determine ultimately is whether the amount of inhibition which they have deliberately and intentionally placed in that acid constitutes an infringement of this patent.

The Court: Well, of course, no matter whether they

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put it in intentionally or whether they intentionally bought some already in, now that I find this out about this, I would go and buy some of this pipe made by the Southern—no, acid made by this,—I can take the combination in there and get something pretty good, or buy the right kind of acid and right kind of pipes to put in there and I would be pretty well fixed.

Mr. Allen Owen: You would still have a reduction in corrosiveness.

The Court: Of course, I haven't found out yet about that in the pipe, how bad it is and how much I would need, but I think when I get through and get that information it will help.

Mr. Wilber Owen: You could not select your pipe in which you are going to put your acid, that is sure. You might select your acid, if you learned one commercial acid had a high degree of inhibition, but you couldn't select your pipe because you are going to put your acid—

Mr. Lyon: Why not?

Mr. Owen: Because you can't go around the country and say I will only treat wells with certain pipes in. The oil companies use all these different kinds of pipe, and this defendant treats wells equipped with all those different kinds of pipe, and they don't go around and say I will treat a well that has this pipe, but I won't treat one that has a different kind of pipe in.

By Mr. Owen:

Q. Doctor, in your testimony yesterday, you gave the results obtained in corrosion tests of the samples Nos. 5 and 7 from the Stella Wilcox well treatment, Nos. 12 and 12-B from the Zahn well treatment, and two samples numbered 15 from the Crawford well treatment? A. Yes, sir.

Q. Will you state whether or not you consider those samples of acid to contain a relatively small amount of a corrosion inhibitor, as that term is used in the Grebe and Sanford patent, and give your reasons for any opinion that you may express? A. It is my opinion that they do contain a corrosion inhibitor, and that that inhibitor is present

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in relatively small amounts. The evidence presented yesterday showed that in each of the tests made, with each of the acid samples from the wells mentioned, that a relatively large reduction in corrosiveness was obtained. By reduction in corrosiveness, I, of course, refer to the fact that these acids gave relatively lesser corrosive action than chemically pure acid, which contains no inhibitor. If one were to obtain the average per cent reduction in corrosiveness represented by the three samples tested from the Stella Wilcox well, for example, on the strap iron, it will be recalled that that value was 44, those samples on the average were 44 per cent less corrosive than the corresponding blank samples of the same strength. The average of the two samples from the Zahn well, the strap iron gave a percentage average reduction in corrosiveness of 45 per cent. The average of the two samples from the Crawford well gave an average reduction in corrosiveness of 70 per cent. It is shown also that substantial reductions in corrosiveness were obtained with each of these acids against similar pieces of metal cut from different oil well pipes. I don't know that it is necessary to repeat my figures of yesterday of the reduction in corrosiveness found, but if one were to take, for example, the average reduction of corrosiveness represented by the Stella Wilcox sample as 44, the Zahn samples average 45, Crawford 70, the average value of those three would be 53. For corresponding acid samples in National Supply Company's pipe, the average of the values would be $31\frac{1}{2}$; of the Oil Well Supply Company's pipe, the average of the values would be $38\frac{1}{2}$; with the Atha Supply Company's pipe, the average of the values would be $51\frac{1}{2}$.

The taking of these average reductions and noting what the average of those values would be in some of the values just mentioned divided by four, for example, would give an average reduction in corrosiveness of 44 per cent which figure, it seems, represents pretty fair value representing the reduction in corrosiveness of these different acids as a group against the different metals taken as a group.

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The Court: Where do I find in the patent the language you referred to?

Mr. Owen: It is in a number of claims. For instance, it is in claim 7, "A relatively small amount of a corrosion inhibitor."

The Court: One is enough. Let me see, there was something I was going to ask you about. What do you understand a relatively small amount of corrosion inhibitor refers to? I take it it always refers to at least two things, when you say one thing relative to something you have got that other something always? A. Yes. Well, in connection with this particular patent I would have in mind a value relatively small, meaning something under, say, 5 per cent.

The Court: Well, why? This is for the benefit of the public and the world, and for chemists, probably. Skilled chemists, to help the public.

Mr. Owen: The statement in the patent itself, "The amount of arsenic compound added may be varied, but we have found that from one to five per cent thereof, based upon the weight of the solution, will be satisfactory for the purpose." That is what the patent states about the relative amount.

The Court: But, it is relative to what?

Mr. Owen: Relative to the volume of acid, I understand. A. Yes. That is as I would understand it.

The Court: All right: That is what I thought.

Mr. Lyon (Interposing): Is it relative to the volume of acid, or relative to the weight of solution as stated in Line 87? A. It might be either, and I still would call it relative because it would be not so different from the five per cent.

The Court: Now, my next thought was what would you say when I refer to this commercial acid we have, whether or not that would fit that definition. A. The question being does it appear that the commercial acid contains a relatively small amount of inhibitor? Yes, I am inclined to think it does.

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The Court: Does it fit the rest of the definition, "Relatively small amount of a corrosion inhibitor, permitting the acid to act upon the rock formation surrounding the well cavity while applying pressure upon the solution and withdrawing the spent acid"? A. May I have that reference, Your Honor? That is in the body of the patent?

The Court (indicating): I was reading right here. I am asking about what Mr. Owen called my attention to. Claim 7 is what you have. You have it right. A. Yes.

The Court: I was using the claim he called my attention to. The question was, first, whether or not that early description of a relative—containing a relatively small amount of corrosion inhibitor would apply to the commercial acid that you tested, and you said yes, it would. Then I asked whether or not your answer would stand that it applied also to that later part of the claim, in other words, does it apply to— A. (Interposing) Permitting the acid to act upon the rock formation.

The Court: Surrounding the cavity while applying pressure upon the solution and withdrawing the spent acid. A. Yes, Your Honor, I believe it would.

The Court: Well, then, so far as you can see the entire claim reads on and would apply, with your definition, to that commercial acid just as well as it does to the defendant's acid? A. Yes. The only point I would feel that the author of the patent had in mind, an inhibition sufficient to serve for practical purposes, while a slight inhibition might not be sufficient to put the acid in such condition that it would be a practical inhibitor.

The Court: Now, I won't attempt to bother my good friend the Doctor with this further, but I call counsel's attention to the decision in the balloon tire case, wherein they had claims for larger tires, but I never found out and the Court of Appeals never found out how much larger they had to get to get within it, and how small they could get to keep without.

Mr. Owen: Well, I think, Your Honor, that the claim must be read with the purpose of the invention in mind as

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it is stated in the specification, and while it is true that these commercial acids could and do contain relatively small amounts of something, we don't know what, different things, perhaps, so that they are slightly less corrosive than chemically pure acid, nevertheless those commercial acids could not be used in a well to obtain the objects sought for and obtained by the Grebe-Sanford invention.

The Court: Well, they never tried it.

Mr. Owen: For this reason: In the first place, the Grebe-Sanford invention gives examples of what they consider to be relatively small amounts of corrosion inhibitor, and it gives one to five per cent. In the second place, one of the objects, as we have already pointed out, of the invention is to insure the delivery of the acid in its, practically its full strength, so that it will operate in the formation. In other words, the object of the invention or one of the results of the invention is to prevent the acid from spending its strength on the pipe or metal with which it comes in contact.

The Court: Has anybody shown me that five per cent will not eat into the pipe?

Mr. Owen: Well, we do know that less than five per cent of a number of the inhibitors mentioned in the Grebe-Sanford patent will give very substantial protection. Right in that connection, I would like to ask the Doctor—

The Court (Interposing): What is substantial protection?

Mr. Owen: Well, substantial protection would be something that would make it commercial, I would say so that it would make it commercially possible to use the commercial acid, in acidizing oil wells, for this purpose, without adding something to it.

The Court: What were those figures I had up there, the first figures for the top column? A. For the strap iron, 15.0 per cent reduction in corrosion.

The Court: Yes, that is what I thought, reduction in corrosion. Well, right over that we get the Atha has a better reduction even than that. You will have to get after

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them. You will have to sue them. They are doing a better job than the others.

Mr. Owen: I think Your Honor has a little misconception there. This merely shows what defendant's acids did to the Atha pipe. That doesn't show Atha is using the acids.

Mr. Lyon: Those are not defendant's acids. Those are commercial acids.

The Court: What was it you said?

Mr. Owen: I said that those figures do not show, are not intended to show, what the Atha Supply Company is doing but they are intended to show what the effect of these different samples of acid have on different pipes, and one of them, the Atha, had a higher rate of protection than it did on some of the others, due, perhaps, to some peculiarity of the pipe.

The Court: That is the iron, isn't it?

Mr. Owen: That is the iron.

The Court: Well, all right. On some kinds of iron is the point, the Detroit Chemical Company wouldn't give half the protection that the next one right down below gives.

Mr. Owen: Which table? A. Yes. The DuPont you have in mind.

The Court: And right in my own mind, I am complimenting the Doctor and counsel for plaintiff for putting all these in. That is what I like when we have experiments. I don't like—it makes me a lot of trouble where they will make several experiments—to have them just bring me the ones that prove some particular theory. I like this way of doing it, and I compliment the Doctor for doing these different things and you for letting me know about it. So we can conjure with them in this way. Not only interesting but likely to reach right and true results with these statistics. I can gather statistics, if I do it unfairly to prove almost anything. That is the reason we have to watch it so carefully. On the other hand, I believe in it because we are thorough about it, careful about it, and we do check up on our theories. So not at all in the way of criticism but in

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compliment to everyone, I am just calling attention to the fact that I can almost dispute any theory you put up because there are those other ways; the one which I dispute may be unfair, and may be more unfair than the theory you set up, but the situation deals with relative things and you do get pretty near to that tire case. You have to be pretty careful. It pretty nearly has to be (if you are dealing in degrees) it pretty nearly has to be formulas, something of that kind, or the public aren't greatly helped by it.

Mr. Owen: Well, may I say a few words right on that point? That in reading this patent the person skilled in the art who attempts to carry out the invention goes to the specification to ascertain what the claims mean. And if he goes to the specification in this patent he will find not only specific examples or a specific example of how much of an inhibitor to place in a certain amount of acid, but he will also find suggestions that other inhibitors, several other inhibitors, as examples, may be used and he says he has found from 1 to 5% of the inhibitor is satisfactory, and the amount varied perhaps according to the activity of the inhibitor. Now, I am going to show by the Doctor that these ranges of inhibition which he has found to be present in the defendant's samples, are well within the ranges that will result from carrying out the invention by using a number of the inhibitors which the patent names.

The Court: What is the percentage of the lowest one, what percentage of the inhibitor is there?

Mr. Lyon: Your Honor, that is what I would like to know. Do you claim, Mr. Owen, that the defendant's well acid contains 1 to 5 per cent of anything which you call an inhibitor?

Mr. Owen: No.

Mr. Lyon: It does not contain $1/25$ th of one per cent of anything you call an inhibitor.

Mr. Owen: No, we do not say that it does, but we say that it does contain something that has the inhibitive effect of the materials mentioned in the Grebe and Sanford patent, when used from 1 to 5 per cent.

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The Court: Is it anywhere suggested that anything less than 1 per cent could be used?

Mr. Owen: No, but—

The Court: You see, there, you are relying on this relatively small amount.

Mr. Owen: Yes. The claim does not say 1 per cent or less than 1 per cent.

The Court: Then where are we going to start, and where are we going to stop? There isn't any suggestion of a definite amount, it just said "relatively." You see we are getting right back to my balloon tire case, where I said that I never could make any calculation unless I knew—I didn't know when they were bigger—bigger than what?

Mr. Owen: Of course the object, as I stated before, must be kept in mind, and if the patent gives a specific example of what could be used for that purpose—

The Court: No, you see, we get right back to the balloon tire case. You get the balloon tire just as quickly as you get any oversize, and you keep on. But where are you going to start, and where are you going to stop? Here you can get the effect of this just as quick as you get any in, you get some of the effect, and you can keep right on until you get to the point where it will not eat any iron.

Mr. Owen: Yes, you can.

The Court: Well, now, how far down the scale the other way are you going to do it? Just put in a very little, and you help it a very little.

Mr. Owen: I think you have got to go to some practical point which makes it possible to use this hydrochloric acid in an oil well without doing severe damage to the pipes.

The Court: You say the lowest was what per cent?

The Witness: The lowest that I reported, or lowest value expressed in average values of the Stella Wilcox samples, while using strap iron, the value was 44 per cent reduction in corrosiveness; the lowest value I found was with the National Supply Company's pipe which is 25.

Mr. Lyon: That isn't the value the court asked for.

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He is asking what per cent by weight of the solution was the inhibitor in there.

The Witness: Oh, I see. No statement has been made as yet as to the inhibitor or the amount of inhibitor.

The Court: Can you tell me what per cent? A. Your Honor, I believe that that is quite likely to be the next thing that counsel had in mind developing, the exact amount.

The Court: You have the figure for it? A. I have the figures and will present it this morning.

Mr. Lyon: It is less than 1/25th of a per cent by weight of a solution, you know that, don't you? A. It may be. I won't say exactly until we get the figures.

The Court: And, you have the figures exactly, so we will get it for this commercial? A. I have the figures, yes, sir, Your Honor.

The Court: That is fine.

Mr. Owen: I want to call attention to one thing before we pass this point, and that is that the claims of the patent do not specify 1 to 5 per cent, and the 1 to 5 per cent is the amount which is recommended in case arsenic is used as the inhibitor. Now—

The Court (Interposing): What we started out with, I was criticizing the patent because it did not give a formula, and you were suggesting that as getting away from that criticism. That is the only way we got into that Michigan. I was saying if this patent doesn't give any formula, what does it do, and where are we going to stop? If you find the least bit in, is it going to be an infringement?

Mr. Owen: I think that the amount, that is the per cent of the inhibitor to the total amount of the acid, is not the important thing but it is the effect. If you can find some other inhibitor by using one-half of one per cent, or a quarter, or one-tenth will be as effective as the 1 to 5 per cent of what the arsenic is, why, then, you are practicing this invention.

The Court: In other words, nowadays since this patent if the natural and economical way of making hydro-

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chloric acid gets some of that inhibitor in, since this patent came out they can't use that particular kind to treat the wells, and they could before?

Mr. Owen: No. I think that this patent—

The Court (Interposing): If nature put it in. If you make it. I take it some of these hydrochlorics that they call commercial, that they find that in those it is cheaper than it would be if they had to go and take that out, isn't that true, Doctor? A. That may be the case in some instances. I—

The Court (Interposing): Have you any idea at all with these commercial hydrochloric acids, putting some of that in to treat wells in there, and get better results, or have you got the idea it has always been in there ever since we began to have commercial hydrochloric acid? A. I think my opinion would be that practically all commercial hydrochloric acids have contained some ingredients that might have had some effect, yes.

The Court: That was my idea.

Mr. Owen: I might call attention, Your Honor, to a chemical case I had a number of years ago in which the process was for the manufacture of arsenate of lead, and the claim called for reacting upon lead oxide with arsenic acid in the presence of a catalytic agent. And, the defendant at first infringed by adding a catalytic agent to its solution definitely for that purpose. A decree was entered and the defendant then changed its process and discontinued the addition of any catalytic agent to its acid, but in manufacturing its acid it left in certain impurities which acted as this catalytic agent, and our Court of Appeals said that it was preventible. We showed that it was preventible. It didn't need to get that in. It was simply carelessness in the process of manufacture, and the Court of Appeals held that it was an infringement regardless of how it got there.

The Court: Somebody had a patent that makes all the world be careful.

Mr. Owen: That is what every patent does, yes.

The Court: I don't think it makes people careful, for instance, about what I do down on the farm. If I have been

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doing it right along, and they get a patent on something, I can keep on doing what I have been doing, surely.

Mr. Owen: Oh, yes, undoubtedly. We can't get a patent that can stop you from doing what you have been doing.

The Court: Supposing back in 1895 when they acidized those wells, do you suppose they had to have absolutely pure stuff?

Mr. Owen: No, I don't think they did.

The Court: But, you can't use that stuff now?

Mr. Owen: Yes, they can. We don't content this patent is entitled to any such construction as that. We don't contend we can prevent anyone from buying commercial acid and using it for treating oil wells to increase their production, unless that acid has been deliberately spiked in order to make it suitable for this purpose, and I say if any acid manufacturer does that—

The Court (Interposing): Does it make a difference? One chap that is careless and makes it, and you can buy the acid with it in, and another chap is a careful fellow and he puts his up to the same height with care, and you can't buy that acid.

Mr. Owen: No. He wouldn't put it up the same height with care; he would put it up deliberately for that purpose.

The Court: But, you see, the varieties you get in commercial acid. And, if I picked deliberately, I take it, from the bargain counter my acids, and I was going to say my irons, but yet if I was drilling a well, and this patent was around me, why don't I pick my iron I use in my well, and pick the acid, and I can do a pretty good job here by doing these two now.

Mr. Owen: Well, I would say if you pick a commercial acid that is not especially prepared to avoid this patent, why, you would be safe.

The Court: Well, I pick my iron, too. I am going to pick them both. I am going to pick the one that will do the best job, and the other.

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Mr. Owen: If you want to do that, we won't object to it.

The Court: I will get as good a job here by doing these pickings, I think, as the defendants.

Mr. Wiles: Oh, no.

The Court: I don't know. If I pick the highest iron and the lowest acids.

Mr. Wiles: No. The best here is 18 per cent, if you got it all, and those fluctuate. The defendants are much higher than that.

The Court: That is 18 what?

Mr. Wiles: 18 per cent reduction. That means it corrodes 82 per cent of the normal corrosion.

The Court: I haven't found out yet the percentage, and you don't say anything about corrosion. You talk about per cent.

Mr. Owen: We talk about reduction in corrosiveness.

The Court: Not in your claim.

Mr. Owen: Oh, no. We don't say anything there. We say, "relatively small amount of corrosion inhibitor."

The Court: I take it, that that is talking about percentage, isn't it, where you talk about that amount there; I think that is talking about percentage.

Mr. Owen: I think so, I think that means that you could take an amount that is sufficient to fulfill the purposes of this invention.

The Court: Well, you have an invention then that if I want to have my pipe eaten, for some reason, I do not infringe, but if I do not want to have it eaten, I do. I use the same thing, I put it down there, I have been using it, I have got some lime on my pipe, say, and I want to get that off, so I put it down there, and if it eats off, on the walls of my well, I will get more oil, and if my purpose was to get that off, I have not infringed, but if that was not my purpose, and I knew it, I have infringed. Well, I didn't know that there was even such a law. I know, criminally, we put folks in jail because of their intent, but I didn't know in this patent game that we did that.

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Mr. Owen: I don't think we do, Your Honor. I don't think that you would be infringing if you used commercial hydrochloric acid that was not specially prepared and spiked for this purpose to do anything that does not come within the terms of these claims.

The Court: But supposing it had been specially spiked, but I did not know it. I look at these figures, and I see this 18.4 over there, and I say, "That is the boy I want," and I go and buy that. If it has been specially spiked, I infringe. If it has not been specially spiked, I don't infringe.

Mr. Owen: Then I think it would be up to us to stop the manufacture of that acid and the sale of it for that purpose.

The Court: Then my infringement depends on my intent and not on what I do, but what my intent is. Maybe that is the patent law, but I didn't know it.

Mr. Owen: You see, my associate calls my attention to this point which I evidently haven't made clear, that this patent covers the making of the acid less corrosive and that—

The Court (interposing): Less corrosive than what?

Mr. Owen: Less corrosive than it was, than it would be under ordinary commercial processes of manufacture. And making it less corrosive for the purpose of using it in making use of this invention. Now, that is what the defendant has done in this case, Your Honor. We will show that the defendant is—we have already shown that the defendant's storage acids are less corrosive than this Detroit sample of commercial acid, but more corrosive than the average of five commercial acids, and we will show that the defendant does not purchase this acid from the Detroit Chemical Company but from other companies, Pennsylvania Salt and General Chemical, whose acids have been or are among the five commercial acids that were analyzed here.

The Court: You are emphasizing this part, the method of increasing the output of an oil well which comprises introducing into the base of such well—then if I put it down

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in there and then would apply some electricity and something to it, such that I changed it and let it do its dirty work, I wouldn't infringe, I take it, but if I do it before I put it down into the well, then I infringe. Is that the breadth of this patent? Suppose I shoot this lead and electricity, or whatever it is, down in there after I have got it in there, and then make it work. You claim I infringe then?

Mr. Owen: No, I would say not.

Mr. Conner: All of these samples—

The Court (interposing): I think you want to disagree with him, don't you?

Mr. Conner: No. I just wanted to get this statement over with. All of the samples that plaintiff is relying on to show infringement were obtained out of the truck tanks of defendant on the surface. That is, we obtained samples of the acid on the surface and not of what went into the well, but if we had not obtained the samples that acid would have gone into the well.

The Court: Suppose you made it that way by the container that you carried it in. You claim that infringes just the same?

Mr. Owen: Yes, sir; we do.

The Court: Now, what I was saying, suppose you put it down into the well and ~~then~~ you put your lead down there and you let this dirty work go on.

Mr. Owen: That would not infringe.

The Court: Then you wouldn't infringe?

Mr. Owen: No; it would not.

The Court: All right. Then you have got your patent narrowed down to a point where it is because they do it, they apply this, let it come in contact with lead as it is approaching the well and before it goes down into the well, but if they wait until it is down in there it wouldn't infringe.

Mr. Owen: I think that is true.

The Court: All right.

Mr. Owen: I will tell you why. If you put your acid

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down in the well and keep it out of contact with the pipe, you don't need an inhibitor when you get down there, but you need an inhibitor when it goes down through the pipe. And you need it for two purposes. First, to protect your pipe from corrosion or being eaten up. Secondly, to insure the delivery of the full strength of the acid into the formation where it is intended to do its work. Now, if you did what Your Honor says, if you put this acid down into the well without inhibitor in and then added inhibitor when it gets down there, electrically or in some other way, why, you wouldn't be accomplishing the purposes of this invention, because you would be destroying your pipe to get the acid into the well. You would be destroying your pipe and your acid also. You cannot destroy one and not the other.

The Court: Even though it is perfectly good, they would be guilty of contributory infringement every time they hauled a tank load under your patent if they hauled it to a well where they were going to put it down.

Mr. Owen: Yes, they would.

Mr. Conner: This patent, Your Honor, does not cover or stop anybody from using commercial acid. Commercial acid was old—

The Court (interrupting): They could put it down into the well.

Mr. Conner: It had been done before.

The Court: Not that I know of.

Mr. Conner: I think Frasch and Van Dyke did use glass carboys.

The Court: But you agree before you got your patent it would be all right for them to have hauled the commercial acid to the well with a lead tank and pour it down into the well?

Mr. Conner: I see no reason why what you were doing before the patent was taken out couldn't be continued. This is what we do—merely take commercial acid and improve the acid to make it less corrosive than it was before. So you have less danger and trouble with corroding of equipment.

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The Court: It doesn't matter how little you do that?

Mr. Conner: Obviously we couldn't claim the infringement existed if the corrosiveness as effected by the alleged infringer is still within the degree of corrosiveness enjoyed by the commercial acid. As the proofs come out we will show defendant's storage acids all enjoy the same degree of corrosiveness, but the acid used in treating these wells is way out of that class.

The Court: But they had already learned to keep their stuff before your patent, this commercial acid with something in it that increased this inhibitor.

Mr. Allen Owen: Not before.

Mr. Wiles: No, sir. That was all gotten up afterwards.

The Court: I say before your patent—

Mr. Wiles: The defendant's patent says take inhibited acid with the inhibitor in it and carry it in a common iron barrel. Now, that isn't what the defendant is doing at all. The defendant takes presumably uninhibited commercial acid, then puts it into a special tank that is got up for the purpose, we charge, of adding an inhibitor, the natural corrosion the commercial acid puts upon it. A slick trick for getting a tank fixed up to add the inhibitor mechanically.

Mr. Wilber Owen: There was no delivery of acid in steel tanks before the Grebe-Sanford invention. They used wooden tanks, not only around the plant in Midland but for deliveries outside. You can't show a single instance where a steel tank was used for delivering acid around the country, but after the Grebe-Sanford patent issued it became known—this defendant discovered, at least—that instead of introducing an inhibitor into its acid as it did during the year 1935 it could get that inhibitor in the acid by fixing up an especially prepared tank. So that although the acid wasn't inhibited when it left the storage place, it became inhibited during the passage in transit to the well where the treatment was to be made, and therefore when the well was treated it was treated with inhibited acid.

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Now, there is no reason why acid cannot be delivered today as it was before the Grebe-Sanford patent, either in rubber-lined tanks or in wooden tanks, or in carboys, but because the defendant owns a patent on a means of protecting a drum for shipping inhibitors or pickling compounds doesn't give it a right to use that invention in order to create an inhibitor during the transit of its commercial acid to the well. There is nothing of that kind in the Gravell patent. It wasn't intended to do that, and the fact that Grebe-Sanford have a patent on the use of that inhibited acid at the well for a specific purpose should not be limited, I submit, to cover the addition of inhibitors to the acids that are so used. It covers the use of inhibited acid. And when that acid is inhibited, whether inhibited by the addition of substances at the well or at the tank station or in transit, doesn't make any difference in carrying out the Grebe-Sanford process.

The Court: I haven't read that patent yet. What are the claims in that?

Mr. Owen: You want the claims of the Gravell patent?

Mr. Lyon: Claim No. 1 says: "The method of preventing an acid solution from attacking a steel transportation or storage drum containing it which consists in dissolving in the said acid solution a material capable of precipitating a substantial protective coating on steel, and allowing the admixture to contact with the inner steel surface of the drum."

The Court: Now, what did you say about the question of putting it in a pipe line?

Mr. Owen: It does not say anything about putting it in or through a pipe line.

The Court: What do you say as to whether, if they put it in a pipe line there and transport it, or, you do that,—can you do that without infringing?

Mr. Owen: Now that Your Honor has asked that question, we say that the defendant does not protect the well tubing in the manner specified in the Gravell patent; that it protects the well tubing by placing—either by placing an

inhibitor in the acid, or in forming the inhibitor in the acid during the transit from the storage tank to the well.

The Court: What do you say about whether the defendant's patent covers putting an inhibitor in it, we will say the same kind that you do, in order to prevent their tanks from corroding? Does their patent cover that?

Mr. Owen: Their claims are broad enough to cover that. We say that was not new.

The Court: Then if they are that broad, why was the pipe line—if they did use that to transfer some of the stuff around through the pipe line, why wouldn't it be an infringement of their patent if you took—if you put the inhibitor in, the same as you do, and let it run through a pipe, to transfer it around your premises?

Mr. Owen: That claim is directed to the protection of the drum in storing or shipping acid.

Mr. Lyon: It says "transporting."

The Court: What do you think about their patent? I am getting off the track, I know that; this is prior art. What do you think about their patent as to whether or not it clearly covers inhibiting by this method they are following now, or does it also cover not only that method but putting in the inhibitor like you put it in? Is there a patent broad enough to cover both of them?

Mr. Owen: Assuming that their claims are valid, they cover placing an inhibitor in the acid for the purpose of protecting the drums, storage drums and shipping drums.

The Court: Do all these inhibitors inhibit by putting a deposit on the thing they are going to eat so that they can't eat it, so that the acid can't eat it, or is there something in there that just dulls their teeth so they can't bite? Which is it?

Mr. Owen: Both, Your Honor. There are some inhibitors, I believe, that form a protective coating on the surface of the metal, and others that dull the teeth of the acid so it can't bite.

The Court: Doctor, to get back to chemistry here, in the defendant's inhibitor does that put a mask on the girl

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so they can't bite her, or does it dull the teeth so that it can't bite her? A. I am not as familiar with the patent referred to as I, perhaps, should be, but from the statements that have just been made it appears that a coating is formed on the metal so the acid does not get to the metal. That seems to be the intent.

The Court: How about the plaintiff's way of doing it? What about that way? What kind of inhibitor is that? Is that a mask or dulling?

Mr. Lyon: The plaintiff uses arsenic, and that is the material or patent in suit we say is the one that does it. They use the very material that is in our patent.

A. To a degree, Your Honor, I feel that it forms a coating, but, furthermore, as it forms a partial coating it sets up a potential in the system such that the acid then cannot so readily react with the iron so that it is stopped in two ways. So, we may say it puts on a coating and also tends to pull the teeth.

The Court: Is that true of the defendant? A. I believe it is.

The Court: Is that true of all of them that you worked with? A. In the case of the inhibitors I think it is quite true.

Mr. Owen: Have you made any tests of the samples Nos. 5, 6, 8, 12, 12B, and 15, with a view to ascertaining what they contain that might cause them to be inhibited?

A. I have made such tests and found them to contain small amounts of copper, lead and iron in solution.

Q. Will you explain how you determined that? A. I determined by quantitative analyses the amount of the copper, lead and iron in solution. Specifically, the iron was obtained by the phenyl-thiourea method. The lead was determined by the di-thizon method. The copper was determined by the thio-carbonate method. I have given the percentages of copper, lead and iron which I found in those samples in parts per million by weight. I have the data in tabulated form in Table No. XI.

(The table was offered and received as PX-160.)

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Mr. Lyon: What do you mean by parts per million; per million of what? A. Exactly that. Parts per million by weight of the material found in respect to the solution.

(The Witness): The analyses were made on the samples mentioned. Starting with sample No. 5 from the Stella Wilcox well, which contained 14.8 per cent hydrochloric acid, there was found 2.9 parts per million of copper, 410 parts per million of lead and 480 parts per million of iron. From the sample No. 6 from the Stella Wilcox, with the same acid concentration, copper 3.6 parts per million, lead 420 parts per million, iron 470 parts per million. And, in sample No. 8 from Stella Wilcox the copper content was 4.2 parts per million, the lead 420 parts per million, the iron 470 parts per million.

Now, the average metal contents of the samples taken from the Stella Wilcox well, that is samples 5, 6 and 8 were, of copper, 3.6 parts per million, lead 417 parts per million, and iron 473 parts per million.

The Court: Does that mean, your first column 14.8 now isn't in the same terms as the next column? A. No, Your Honor.

The Court: This is the per cent of the solution? A. That just happens to have been the concentration of the acid.

The Court: I understand you analyzed to get this per cent, or did you analyze the whole thing and just say 14.8? A. Well, what would be done would be to take a given mass of solution and then analyze that and calculate how many parts of copper per million parts of the mass of the whole.

Mr. Owen: Now, will you explain the other figures on the Exhibit PX-160? A. Analyzed in a similar fashion, the samples from the Zahn well, sample 12 contained 2.7 parts per million of copper, 410 of lead, and 410 of iron.

Q. Right at this point, Doctor, I am going to ask you to tell the court of the incident you explained to me where merely stirring something with a copper spoon had a decided effect. Will you tell the court what that was? A.

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Well, I think presumably the thing I referred to at that time was rubber latex. The rubber latex is often called the milk of rubber, the white fluid material which, if allowed to flow out on a surface, and dry, will become rubbery and elastic, and one can pick it up and stretch it. But, I have done this experiment. I have stirred some of that latex in a beaker with a copper wire for a very short time, and then poured some of that latex on the surface and it would not set, it would remain indefinitely sticky and gummy. And, the use of latex as coatings is often prohibited by the fact that traces of material will greatly alter its properties. That small amount of copper will greatly alter the property of latex.

In the same connection, if I may mention it, speaking of traces of copper, I was curious to see what references I could find with reference to the effect of that. I found this statement which occurred in Alexander's Colloid Chemistry published in 1937, that less than one part per million of copper in coffee can be tasted, which seemed a bit surprising at the time. And then I found another statement to the effect that six-tenths of a part of copper per million are essential before free-swimming oyster larvae will set. Copper must be present, but that small amount, six-tenths of a part per million, is sufficient.

Then I found another statement, how true I do not know, that traces of copper, such, for example, as are found in grandmother's copper preserve kettle, inhibit bacteria and moulds, and minute amounts of copper sulphate have been used to kill troublesome algae, etc., in reservoirs. Those were references that I found in some of the chemical literature.

Q. (By Mr. Owen) Doctor, did you also analyze the storage tank samples No. 14 and 20 for their metal content? A. Yes, sir, I did, and have a table showing the results of my analyses.

(The table was offered and received as PX-161.)

The Court: Before you leave this other one, Doctor. Which of those are inhibitors? A. Well, Your Honor, I

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have made quite a detailed study of that, and I have a table which I expect I will present shortly showing the effect of these things. It is probably no anticipation to state that the copper is really the bad actor there.

The Court: Of course, iron is not at all? A. Very little, if any.

The Witness: PX-161 gives the analysis of the storage samples. The N14B, to which we have previously referred, full strength, not diluted, showed 1.5 parts per million of copper; 10 parts per million of lead; and 27 parts per million of iron. Corresponding values were obtained for the other samples. S14B showed 1.5 parts per million of copper; 8.7 parts per million of lead; 13 parts per million of iron. Sample N20B, 0.37 parts per million of copper; 5.5 parts per million of lead; 15 parts per million of iron. Sample S20B, 0.56 parts per million of copper; 16 parts per million of lead; 21 parts per million of iron. These are the amounts of those metals which I found in the samples of acid in the strength in which I received them.

I have another table showing the metal content of these same samples, diluted to the strength of the well samples. That is my Table XIII.

(The table was offered and received as PX-162.)

Mr. Owen: PX-161, Your Honor, is before the acid is put in the truck and PX-162 is after it is put in the truck and diluted about 50% with water. The purpose of PX-162 is to enable us to compare the amounts of these metals in the diluted storage samples with those in the truck samples (PX-160), the dilution being the same on both of these exhibits PX-160 and 162.

The Court: Maybe the Doctor can help me a little by some suggestions as to why from one tank he got twice as much copper in it as the other. That is in the tank, is it? A. That is the storage tank, Your Honor.

The Court: Well, in the storage tank what would be the explanation of that? What could be? I hadn't hoped for the best, but what do you guess it might be? A. Unfortunately I haven't an explanation for that. In this case

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it is evident copper got in somewhere. The acid may have come in contact with that copper. Where that copper may have been, we have no evidence, so far as I am concerned that would show that.

Mr. Owen: I think, Your Honor, the differences in the amount of copper in the storage samples might and probably did result from the fact that the defendant bought its acid from two different sources, and they had two tanks, so when they would get in a carload from one source they put that, perhaps, in one tank which was run down, and when they get a carload from another source they put it in the other tank.

Mr. Lyon: Those are wooden tanks. I don't see how the copper got into the wood. I don't know.

The Court: Let's see; can I go back to the other formula that you are talking about the acid, where they bought the acid? Can I go back and trace what kind of acid they bought? They must have bought some from one of these, Pennsylvania Salt Company or General Chemical Company.

Mr. Conner: Yes, the third and the fourth acids on the list.

The Court: Yes. I will just look at these and see how they go. Well, on the whole, they are buying about as poor an inhibitor as there is, aren't they? The poorest. They have got the two poorest inhibitors there are, isn't that right? A. Just about, as far as these tests indicate.

Mr. Wiles: That means the poorest, probably, of the commercial acids.

The Witness: The amount of copper found in the average of the two Zahn samples, namely 12 and 12B, was 3.1 p.p.m.

The Court: You are looking at PX-162. A. It happens, Your Honor, that I am referring to something beyond that in my own notes. I have extra copies of these tables, I find, for making the comparison.

(The table was offered and received as PX-163.)

Witness (continuing): On the table to which I am referring now is found the data, analysis data of samples 12

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and 12B from the Zahn well, the analysis of N14B diluted to the same strength as the samples from the Zahn well, which was 14.5 per cent, and the analysis of the sample S14B diluted to the same extent. The last two are the storage tank acids, and the first two are the truck tank acids.

Mr. Owen: I might state, Your Honor, that this Zahn well treatment was made on the day following the taking of the N14B and S14B samples.

The Court: Now, then, let me see. I really don't see, so I will think out loud and have you correct me. The 12 Zahn is just as it was taken from the defendant's Zahn truck?

Mr. Owen: Yes, at the well. That is also true of 12B. There were two samples taken at the same time and split, so that 12 and 12B are really parts of the same sample, from the same truck. The N-14-B was taken from the north storage tank and the S-14-B was taken from the south storage tank.

The Court: And after you have taken it, you have diluted it down so it would be the same acid strength as that that you had taken from the truck. A. That is it.

The Court: Now I have the whole picture.

The Witness: It will be noted then that the composition of the first truck tank sample indicated as 12 Zahn contained 2.7 parts per million of copper, 410 parts per million of lead, and 410 parts per million of iron. The other sample, 12B, contained 3.5 parts per million of copper, 460 parts per million of lead, and 350 parts per million of iron; or an average of metal contained in these two samples, copper 3.1 parts per million, lead 435 parts per million and iron 380 parts per million.

Of the storage tank samples, N14B contained 0.72 parts per million of copper, 4.8 parts per million of lead and 13 parts per million of iron; while the sample taken from the other storage tank, S14B, and diluted, contained 0.69 parts per million of copper, 4.0 parts per million of lead, 6.0 parts per million of iron; or the average metal content of these

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two samples is, of copper 0.70 parts per million, of lead 4.4 parts per million, and of iron 9.5 parts per million.

Now, comparing the values, first of copper, it will be seen that the copper content of the truck tank sample, the average value is four times that of the storage tank sample, approximately four times.

The Court: You mean the quantity, the weight. A. The quantity, that is right, Your Honor. The amount of copper per unit weight is four times as great in that truck tank sample as in the storage tank sample. Of lead there is about ninety-nine times as much in the truck tank samples as in the storage tank samples. And of iron about 40 times as much in the truck tank samples as in the storage tank samples.

The Court: I can work out a theory as to the increase in lead and iron, but I have a lot of trouble about that copper. A. I have had trouble, also, Your Honor.

The Court: You find it quite easy, don't you, to explain why the lead and iron increases? I don't know about the proportions or the amount. A. Yes, Your Honor. After having read the depositions of the structure of the truck tanks, and so on, why, I can understand where the lead might have come from, and the iron. And, there is some copper in the lead which dissolved.

The Court: That may be the answer, then. A. That is, probably, a part of the answer. Whether there is enough lead there—

The Court: It is usual to have some copper in lead? A. It is not uncommon at all, and I have reasons to believe that in this particular lead there is some copper.

The Court: That may be understood, then. If there is a trace of copper in lead, at least for the present I can see how, if the lead is coming off and going over to the iron, and there is some copper in it— A. (interposing) That copper is bound to go in, yes. Such copper as is present will go in.

Mr. Lyon: As I understand it, witness, a trace of

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copper is not an uncommon impurity in lead, is that right? A. In commercial leads copper is sometimes found.

The Court: Then you are inclined to think—I will put it this way: have you figured out any better theory now as to how that could happen, than that? A. Well, I haven't figured out a better theory to account for some of the copper, at least.

Referring to my table XIV, PX-163, the last line at the bottom of the page means that there is approximately four times as much copper in the Zahn samples as there was in the diluted 14B samples, and 99 times as much lead and 40 times as much iron.

I made up a similar table showing the relative increases of copper, lead and iron in the Stella Wilcox treating acid as compared with the 14B storage acid.

(The table was offered and received as PX-164.)

The Witness: In this table is given the data showing the amounts of copper, lead and iron in the three samples from the Stella Wilcox well and from the two storage samples labeled N14B and S14B. The Stella Wilcox samples are numbered 4, 6 and 8. Perhaps it would be sufficient to give the average copper, lead and iron content in the Stella Wilcox samples, which would be 3.6 parts per million of copper, 417 parts per million of lead and 473 parts per million of iron.

Q. And how much increase was there in the copper, lead and iron contained in the Stella Wilcox samples over that contained in the 14B storage samples when diluted to 14.5% strength? A. The average metal content of the two storage samples was 0.70 part per million of copper, 4.4 parts per million of lead and 9.5 parts per million of iron.

The Court: Isn't that just the same as in PX-163? You didn't bother to run it again? A. No, Your Honor. Simply we made the one analysis, and a comparison then of the metal content of the Stella Wilcox samples to the storage samples mentioned showed 5 times as much copper in the Stella Wilcox truck samples as in the storage sam-

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ples, 95 times as much lead and 50 times as much iron. It will be understood that those figures are approximate, although nearly exactly correct.

I have made a similar table comparing the Crawford samples No. 15 with the storage samples numbers 14 and 20.

(The table was offered and received as PX-165.)

The Witness: That table shows that the average copper content of the two samples 15 from the Crawford well contained 4.8 parts per million of copper, 53 parts per million of lead and 210 parts per million of iron. The average metal content of the four different storage tank samples examined had 0.46 parts per million of copper, 4.7 parts per million of lead and 8.9 parts per million of iron. That is an average of the four storage samples N14B, S14B, N20B and S20B diluted to 14.5 and 15.1% hydrochloric acid, respectively.

Mr. Owen: Now, is it clear, Your Honor, what these tables XIV, XV and XVI show? (PX-163, 164 and 165.)

The Court: I think so.

Mr. Owen: I will ask you, Doctor, have you analyzed any sample of the lead plate which you understood was taken from one of the defendant's truck tanks? A. We have.

Mr. Owen: That is one of the samples that has been covered by the stipulation. Mr. Babcock gave us one of those strips they put down in the tanks when we were taking testimony at Mt. Pleasant.

Mr. Lyon: That wasn't supposed to be necessarily one of the lead strips in these particular trucks. It was one of those they were using—

Mr. Owen: It was given to us as representative of the lead you were using.

Mr. Lyon: Was it one of the lead strips that came out of the tank?

Mr. Babcock: No.

Mr. Lyon: There might be variation, so far as I know, in lead strips. That is the only statement I can make

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about it—that he gave you one. - Had it been used at all?

Mr. Owen: I think not.

Q. (By Mr. Owen) Now, will you state what you found that lead sample to contain? A. We found the lead sample to contain copper. As to how much I am not sure I have the figures at my finger tips here.

Mr. Owen: Regarding our obtaining of that lead strip, we were taking testimony over at Mr. Pleasant and Mr. Edwards explained to us how they polarized their tanks by putting this lead strip down in the acid and attaching a storage battery to it, running the battery down. I asked him—"Q. Have you any of the lead strips in stock which you use in polarizing a new tank? A. Yes. Q. Here in Mt. Pleasant? A. I think so. Q. Would you furnish us with one of those strips if we pay for it? A. Yes." (Mr. Owen reading from testimony.) And he gave it to us. We went over to their storage warehouse, Mr. Edwards picked it out and gave it to us.

The Court: All right. I will admit the analysis.

Mr. Owen: I will say, Your Honor, I don't concede that the burden is on us to account for the presence of these metals in their treating acids. We found them there and we are giving Your Honor the benefit of what we found and of any possible explanation we can offer, but it is not a burden that we must sustain to show how they got there.

Q. (By Mr. Owen) Now, Doctor, you heard what I stated to the court about the possible sources of this copper but Mr. Wiles calls my attention to the fact that that is not testimony. Will you state where you think it might have come from?

Mr. Lyon: If the Doctor said he doesn't know, I don't see why we should have guesses. If they are relying on this copper as being what the defendant added, it seems to me if anybody is going to furnish evidence on that, he should lay a foundation as to knowing something about it. I don't understand the Doctor has ever seen the defendant's system or examined it. I don't even know what explanation he has had of it.

The Court: I will let him answer it.

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A. Well, as I stated this morning, if lead contains copper, that copper will go in solution and we know that it is highly probable that the lead used contains some copper. That copper will go in solution. Now, if there is more copper in the solution than can be accounted for by the lead used, it must come from somewhere. The only obvious source would be from the equipment. Just how the tanks are put together, whether by chance there is brazing in the tank—as it seems to me I heard that word used yesterday—it would imply brass somewhere. I can't quite believe the tanks would be brazed. I am not suggesting that, unless perchance the tanks are brazed. The tanks may have some copper fittings; there may be valves or there may be copper in the pumps somewhere for transport of the acid, through which the acid would pass and pick up some copper. In other words, it appears the copper must come from some of the equipment, from somewhere. Not being entirely familiar with the equipment, it would be mere speculation to say where it does come from.

Q. Mr. Owens: It is in evidence that samples of Mt. Pleasant tap water were delivered to you. Do you recall having received them? A. I do.

Q. And, did you analyze them? A. I did.

Q. Could the copper in the defendant's treating acids used at the Stella Wilcox, Zahn, and Crawford wells have come from the Mt. Pleasant water used to dilute the storage acid? A. No. The copper content of the water was less than two hundredths of one part per million.

Q. Now, Doctor, have you conducted any tests to ascertain what, if any, effect the presence of small amounts of lead and iron and copper, or either of them, in approximately 15 per cent hydrochloric acid solutions has on the corrosive effect of the acid on iron or steel? A. We have conducted a fairly extensive series of tests of that type, tests in which small pieces of iron of the size previously described, strap iron 1 inch by $\frac{7}{8}$ ths by $\frac{1}{8}$ th inch thick, suspended in 15.1 per cent acid solution, 50 c.c.'s of said solution in the same type of container previously used, at

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the temperature previously referred to, 85 degrees Fahrenheit, the same length of time, 16 hours. We have tested the effect of adding to originally pure acid different amounts of copper, increasing amounts, different amounts of lead, different amounts of iron, and then various combinations of two of each of these different materials in solution, and we have such data available.

Q. Also, as I understand, various combinations of all three of them, did you not? A. Yes, we did that also. We made one fairly extensive series in which we used combinations of all three of the metals: copper, lead and iron in combination.

The Court: Let me ask you as to your final conclusion on all this; do you find more copper and more lead and more loose iron floating around in this acid in the transportation tanks which you can reasonably account for than if they buy commercial acid, pump it in the ordinary way through the brass fixtures that are likely to be around, and into a tank with the lead in it, lead got it in,—do you find any more than you think would be accounted for in that way? A penny's worth in the water, perhaps. Take it together. Do you think you have found more of the free iron and lead and copper than could be accounted for in that way, if handled in the ordinary way? A. Well, it would seem that the acid must have been handled a number of times in one way or another between the point of manufacture and the point of storage in the storage tank, handled by various devices, and that would seem to represent about the normal amount of elements that one might expect the acid to take up in transportation or in handling and there is, of course, much more of these elements in the truck samples than we have found in such storage samples. That is about the best argument, it seems to me.

The Court: To put it in a rough sort of a way, in a wicked sort of way, do you think that they stuck some of this particular stuff in there? Is that your conclusion? Or, is it your conclusion that this can be accounted for by

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the handling? A. Personally, naturally, I prefer to think that in their handling in some way that got in.

The Court: You think in the normal way of handling—in the normal ordinary handling of this, assuming now that they have the lead in, that is something they have added, but that the amount of lead they have got in, and the way they have got that arranged in their transportation tank, you think this quantity can be accounted for by that lead in the acid, and the iron that is there, added to what little will come in through commercial acid, or with a commercial acid, and the ordinary uses of it with ordinary pumps and tools? A. It just happens that I have not analyzed any commercial acid with copper content as high as we find in the truck acids, and I would hesitate to answer that question without having some basis for it.

The Court: Well, you see, I am interested right now, I am wondering whether I have got enough to make me suspicious that they—that is, whether you intend by this proof to create a suspicion—it is all right to do it, but there is something—put them on their proof—that they have added something, or whether the result of all of it, as a result of this you think I should draw the conclusion that it is all explained by the natural, ordinary use of this, coupled up with the plates of lead.

Mr. Owen: I think that that is all we contend, Your Honor. We do not contend that they have placed a chunk of copper, or any copper oxide or chloride in these tanks.

The Court: The rest of it then, all except that plate of lead, is just the ordinary way of handling this material.

Mr. Owen: No, it is not an ordinary way.

The Court: Well, that is what I want to know. Just what is it?

Mr. Owen: It is perfectly possible to handle this material in such a way that there will be no more copper and lead in the acid when it is put into the well than there is when it is in the storage tank.

The Court: You are talking now about not using the lead?

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Mr. Owen: Not using the lead, and not using the steel tanks to transport it.

The Court: Well, all right. We will couple that up then. You claim that they should not use steel tanks with the lead. Is there anything else now that they have done?

Mr. Owen: If they use copper or bronze fittings, and the copper comes from those, they should not use those.

The Court: I am asking whether or not there is any claim that it is more than the ordinary use of copper—

Mr. Owen: With the equipment they use, no, it is no more than what you might naturally expect—

The Court: You claim that in order to avoid the infringement of this they have got to be careful to see to it that there is not any copper around in any of their pumps, or in any of their tools?

Mr. Owen: Yes, they have got to see to it that they do not add any of those inhibiting materials to their acids.

The Court: Well, I was getting at your contention about this.

Mr. Owen: If they use conventional methods of transporting their acid they won't have these impurities.

The Court: Well, now, I understood the witness, and he explained to me in the ordinary use of it you might get some of these things added, and there might be some copper quite naturally, and ordinarily, as I understand it, in some of the tools, and that there might be a little bit in the water. Not enough to account for anything much.

Mr. Lyon: Certainly they wouldn't allow us to use the Gravell patent, which is earlier than theirs.

The Court: Have you got anything, Doctor, here from which you can get any idea of how much of this is from the iron tank and the lead plate in the iron tank, and how much from all these other sources outside that have been referred to in the testimony? Is there any way at all?

A. I haven't enough information to make any exact quantitative calculations, Your Honor. I regret that I haven't.

The Court: I see the difficulty of it. And these questions aren't in criticism of anybody at all. I understand

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this, that you don't complain at all about the amount to be found in any of these storage tanks?

Mr. Wiles: No.

The Court: Then we won't worry about whether they got it in there through some pipes with brass on or not.

Mr. Wiles: No. It is in there.

The Court: Then, what you are talking about is entirely the increase that comes from the lead plates with the iron tank?

Mr. Wiles: Of course, we don't know exactly where it all comes from. It comes somewhere in their method of handling. There is no doubt about that. My own personal guess—we haven't samples of these tanks, but we do know there was a copper bearing steel which is rather extensively used for tankages, because it doesn't corrode as easily as straight steel, and I would make a guess that they probably have copper bearing steel tanks.

The Court: Do you complain about that?

Mr. Wiles: Yes, I don't complain about anything they do excepting putting inhibited acid down a well, and I don't care how they get it inhibited.

The Court: Some of this inhibition you are proving evidently it came in there perfectly naturally, and wouldn't be hardly possible to avoid. That is what we find in this storage tank, I take it.

Mr. Wiles: There is practically nothing there. The copper is way down.

The Court: There is some there?

Mr. Wiles: Traces, certainly.

The Court: And, as I understand it now, maybe I am wrong, it is because they increase that as a result of using those lead plates and an iron tank?

Mr. Wiles: Yes. Probably a copper bearing iron tank.

Q. (By Mr. Owen): You stated that you had made tests with different additions of copper to 15 per cent C. P. hydrochloric acid, and with different additions of lead and of iron. Will you state in a general way, before going into the details of your experiment, what those tests showed?

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A. Those tests show that a very small amount of copper tended to inhibit the corrosive action of the acid against iron; and that as the amount of copper was increased, the corrosive action was decreased, of the acid.

Q. Within any limits? A. Yes. The greatest reduction in activity came with very small amounts of copper, one part to three or four parts per million is the greatest rate of decrease. Reaching three and a half parts of copper per million with copper alone with the C. P. acid, the per cent reduction of corrosiveness was 33 per cent, meaning that the acid was about 67 per cent as active as it would have been had the copper not been present.

Q. Now, let me understand you, doctor, was anything else added to that C. P. acid besides the 3.5 parts per million of copper, in this test that you have just referred to? A. No, nothing but the 3.5 parts per million of copper, and the corrosiveness of the acid was reduced 33 per cent.

Q. Now, can you give similar information regarding the addition of lead? A. 320 parts per million of lead gave a reduction of corrosiveness of 12 per cent without adding anything but the lead. It happens that the 320 parts per million of lead isn't far different from some of the lead we found in the acid samples. The extent of reduction in corrosiveness was 12%.

Q. How about the 3.5 parts per million of copper being about what you found in the defendant's treating acids? A. That was close to what we found in the defendant's treating acid.

Q. And have you carried the addition of copper beyond 3.5 parts per million? Did the inhibitive effect increase with the increase in proportion of copper? A. Not nearly at such a rate. For example, 5 parts per million of copper gave a reduction in corrosiveness of 37. 3.5 parts gave a reduction of 33; 10 parts per million, 38; 40 parts per million, 39.

Q. So that the 3.5 parts per million appears to be about the critical point of the increase in the reduction in corrosiveness due to the addition of copper, is that true?

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A. It was a critical concentration. It gave nearly as high a reduction in corrosiveness as much greater concentrations.

Mr. Lyon: Did you say how much 1 part per million will do? Have you given that figure? A. I haven't given that figure. 1 part per million, 20% reduction in corrosiveness. I have no figure lower than one part per million of copper. I have figures higher than 40. I have figures up to 100 parts per million, which gave 40% reduction in corrosiveness. That was essentially the same as 40 parts per million.

Q. What were the results of your tests adding iron to the C. P. hydrochloric acid? A. We added both ferric iron and ferrous iron; adding ferric iron gave relatively little effect—as much as one-thousand parts per million gave an effect represented by per cent reduction in corrosiveness of 4%.

The Court: How can you say that iron is an inhibitor? If it was you couldn't use any hydrochloric acid down there at all. You will have iron down there and it will eat the iron. A. Your Honor, there is the possibility of iron existing in two forms—ferric and ferrous, setting up some type of reaction of the metals which might bring about some type of inhibition, but, as a matter of fact, we found there was exceedingly little inhibiting reaction of iron and the ferrous iron gave us no inhibition. As we have shown, the ferrous iron has apparently no inhibiting action; if it happens to be in the ferric form it might have a slight inhibiting action.

Q. (By Mr. Owen): In what form did you add the copper and the lead? A. We added these metals as chlorides. We added copper chloride and lead chloride to the C. P. acid.

The Court: This iron you found was not the free iron? A. No, in the form of a salt. In the form of iron chloride. Probably very nearly all of the iron that had been eaten off the tank was in the form of salt in the solution.

The Court: You see, I didn't have that idea about it. Now, the lead that you find, as I understand it, is because

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of some sort of electrical plating action that started to go across to the iron walls somewhere and it got lost in the woods on the way over, and you found it floating around in there? A. Yes.

The Court: Has that got into lead oxide or lead something? A. Yes, lead chloride.

Mr. Owen: Just the same reaction that forms the iron, of course, that forms iron chloride. A. One forms iron chloride and the other lead chloride.

Mr. Wiles: The copper also is in the form of a salt in solution. A. Yes. Any copper present likewise would react with the hydrochloric acid and form a copper chloride, and that would be as a salt in solution.

Q. (By Mr. Owen): And I believe you testified that the copper and the lead and the iron which you added to the C. P. hydrochloric acid in making your tests was in the form of chlorides, copper chloride, lead chloride and iron chloride? A. They were in the form of chlorides before we added them to the pure acid, yes.

Mr. Lyon: Would the copper chloride tend to plate out on the wall of the tank under the battery action the same as the lead chloride? A. Essentially the same.

Mr. Lyon: Excuse me, Mr. Owen, but the witness started to tell us the effect of the addition of different amounts of lead. He gave the answer on copper, and started with lead, but he did not finish that. I should think that you would want him to finish that before he goes into the combinations.

The Witness: I referred to the concentration of 320 parts per million of lead, and stated that that much lead in the acid caused a reduction in corrosiveness of 12 per cent. Increasing amounts of lead produced relatively smaller effects. 620 parts of lead per million gave a per cent reduction in corrosiveness of 14 per cent, and 1000 parts per million gave a reduction in corrosiveness of 15 per cent.

Mr. Owen: Doctor, how did the most effective proportions of lead and copper in your tests, where you added those metals to the C. P. acid, compare with the amounts

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of lead and copper chlorides which you found in the defendant's treating acids? A. Maximum,—close to maximum effects were reached when three and a half parts per million of copper to 320 parts per million of lead were taken together. Taken together in those proportions, they gave a reduction in corrosiveness of 38 per cent.

Q. Have you a table, Doctor, which shows the results of your tests, in which you added copper, lead and iron to C. P. hydrochloric acid? A. Yes, I have such data in my table XVIII.

(Table XVIII was offered and received as PX-166.)

The Court: When you take that combination of iron and copper, which you mentioned, in which you get your maximum of inhibition, as I understand it, do you explain that particular portion—does that advantage result from the fact that there is a coating on the thing that you want to inhibit the action on? Or does that all result from the salts that are in solution? It seems to me that there are two kinds of inhibition that bother me in a way. Is there any way that you can give me any idea as to their comparative force in producing this inhibited result? A. In a general way without going into detail of the mechanism I think it would be quite safe to state that the coating effect of copper in an amount represented by as little as $3\frac{1}{2}$ parts per million would be sufficient to so coat the iron that the action of acid would be very greatly inhibited as we do find it; that there is sufficient copper there to form probably a complete molecular layer over the entire iron surface.

The Court: Do they call something that does that an inhibitor? A. They might, yes, because inhibition really refers to a cutting down of a process, and that would certainly tend to cut down the process considered as the whole.

The Court: There are,—or, aren't they recognized as two decidedly different things, one that would put a coating on something and fix it so it can't be equal to the acid like my Parker rustproof case, and another thing that you put something into it so that they will associate together side by side, and one won't eat up the other? It seems as though one is almost—A. (Interrupting): It is to a degree.

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The Court: And this very thing I am talking about enters quite a little bit into the theory that later the plaintiff wants to talk to me about, about the using up of this acid and making it so it isn't desirable for its use in the rock. This very thing you and I are visiting about now gets right over into that problem, in my judgment. A. Of course, if the acid is inhibited and the inhibition consists in the deposition of metal, say copper on the iron, in such a way that the action ceases, why then there is no further need to worry about the action of the acid on the iron. We can say that the system is inhibited. But if the acid had contained none of this inhibitor, copper, to set up this action on the surface, why then the reaction could have gone on unhindered quite indefinitely.

Q. (Mr. Owen): What effect would that have upon the strength of the acid? A. The strength of the acid would decrease in that case.

Q. (Mr. Wiles): I want, if I may, to bring out the difference in the two theories you have spoken about. As I take it, one of the explanations is an unbroken uniform or continuous coating of copper, which keeps the acid off the steel. A. Right.

Q. And now, the other one is exemplified, as I understand it, if the coating is spotted, copper, just spots here and there on steel. Now, will you try to make clear the mechanism of how those spots of copper would prevent the acid from attacking the steel in the uncoated parts? A. Probably the most substantial explanation would be that one of the constituents might be absorbed on iron, and in that way tend to change the polarization of the system. For example, in some of the old style dry batteries that I think of, the old carbon cells in which the two electrodes were placed down in the electrolyte, current would flow for a short time and the current would stop, stop because the system had become polarized we say. The hydrogen could not escape. By adding some oxidizing agent to the system which would make possible the liberation of hydrogen, hydrogen would be liberated and the current would flow and continue. And

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it is just about the same type of picture which is offered to account for the inhibiting action of metals such as iron—

Q. (Mr. Wiles interposing): Can't you put them on the blackboard so we can all see it? A. Well, suppose one has two electrodes, iron and lead, the electrolyte being hydrochloric acid, and we will assume fifteen per cent hydrochloric acid. Now, it is a little dangerous to speculate off-hand which way the current is going to flow in that system. One might predict that the iron would go into solution and the current would flow that way, toward the lead electrode, and the iron would be deposited. That wouldn't be a bad speculation because from the table of the electromotive series one might expect that.

But when one actually carries the experiment out, he finds that it goes the other way, that the lead goes into solution and deposits on the iron. And so, if one has a coupling of that sort, it is true that a certain amount of the lead, as the lead from the plates in these tanks, will go into solution, pass through the acid, and the lead will be deposited on the surface of the iron.

Mr. Owen: Well, now, Doctor, when the lead goes into solution, what is it in the electrolyte? A. When the lead goes into solution, when it leaves the electrode in the electrolyte, it is lead chloride.

The Court: And if you were to stop that at any instant and analyze your solution you would find some of those that, as I have said before, got lost, whatever you want to say, they haven't yet become deposited and they have left the lead, isn't that right? A. That is right.

The Court: You would find some. A. In solution.

The Court: But the probability is you will find some iron in solution. A. And in the beginning there will be a certain amount of iron going into solution as well as lead, so both lead and iron would be found in the solution.

The Court: But that, for some reason, doesn't seem to be strong enough to swim clear across, and you don't find that coating on the lead, as I understand. A. That is right, Your Honor. It doesn't tend to come out forming a coating on the lead.

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Mr. Owen: Now, Doctor, will you explain what the reaction is when the lead goes over and coats on the iron? A. If the lead goes over as lead chloride, when it comes in contact with the iron it deposits and forms metallic lead. It goes from the lead in solution to metallic lead.

Q. If the lead was coated on this iron electrode in the presence of hydrochloric acid what would occur? A. Of course, the current, flow of current would stop then, because, in effect, one would have two lead electrodes.

Q. Then, what would take place if both electrodes were either lead or covered with lead? What would take place? A. Well, the acid would tend to eat them off there.

Q. Before we leave this question, I just want to ask the Doctor if this field of electro-chemistry is not a different field from that in which you are devoting your time at the present time? A. At the present time, yes, that is correct.

Q. And you do not pose as an electrochemist of the last word, do you? A. At the present time, you mean? No.

The Court: I just want to thank you for having answered my questions.

Q. What you have done is to just answer the judge's questions to the best of your ability? A. I have, without attempting to refresh my mind on the points.

Mr. Wiles: I think there is one question that might be asked, which might help to clear this up, and that is, the Grebe and Sanford patent, Doctor, gives a specific illustration of arsenic as an inhibitor. Would you differentiate the mechanism of inhibition by arsenic from the mechanism of inhibition by copper, except as there is a difference in the degree of effectiveness?

Mr. Lyon: Is he speaking now of what distinction the patent makes, or outside of the patent?

Mr. Wiles: The patent does not mention copper.

Mr. Lyon: Oh, yes, it does. It defines an inhibitor in line 75, page 1, as a substance capable of inhibiting the attack of the acid upon metal surfaces, *e.g.* of iron or steel, copper, etc., with which it comes in contact.

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Mr. Wiles: I am speaking of the inhibition of the acid against steel and copper on the one hand, and by arsenic on the other. Would you differentiate between the mechanisms, or are they the same, approximately the same, in your judgment? A. Well, broadly speaking, I should say that they are the same, broadly the same.

Q. (Mr. Owen): Will you refer to your Table XVIII, PX-166, and explain what it shows? A. In the table I have brought together the data obtained when small amounts of copper or of lead or of iron or of combinations of these metals were used, in studying the per cent reduction in corrosiveness. At the beginning of that table, the solutions are numbered, 1 to 7, consecutively, and there are indicated the results obtained when copper in amounts ranging from 1 part per million to 100 parts per million are used.

The Court: That is just your own arbitrary selection of these amounts? A. It is.

The Court: They are not samples or examples taken from any place, but you just fixed those up? A. I selected them to cover a sizeable range.

The Court: That is the way I understand it? A. And the percentage of reduction in corrosiveness runs from 20 to 40. The greatest effect comes with the increase in the small amounts of copper from 1 to $3\frac{1}{2}$ p.p.m., the reduction stepping up from a 20 per cent reduction at 1 p.p.m. to a 33 per cent reduction at $3\frac{1}{2}$ p.p.m. From 15 p.p.m. to 100 p.p.m. of copper the increase in corrosiveness is only 3 per cent.

Mr. Lyon: Didn't you find copper in the commercial acids that you analyzed? A. Yes, we did. From 24 hundredths parts per million to 37 hundredths parts per million, I believe.

The Court: You think I would be justified in reaching the conclusion that if you increased this beyond 100 parts per million of copper you would never get very much above 40? A. I wouldn't expect to, very much.

Q. (Mr. Owen): Well, now, Doctor, refer to the additions of lead and state what your tests show in that respect. A. Ten parts per million of lead added to the chemically

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pure acid gave a per cent reduction in corrosiveness of 4. 40 parts gave a reduction of only 3%. I cannot account for that. It just happened that way. When you get up to 160 parts, you have a reduction of 6%. 320 p.p.m. gave 12 per cent reduction; 420 parts, 13 per cent reduction; 620 parts, 14 per cent reduction, and 1,000 parts, 15 per cent reduction. This was lead alone. No, copper.

Q. (Mr. Owen): So that the greatest percentage of increase there appears to have been from 160 to 320 parts per million; is that right? A. Yes; that is right.

The Court: And there isn't any theory that you know of to explain that? A. No.

The Court: It just does it? A. That is right.

Q. (Mr. Owen): How does 320 parts per million of lead compare with that found in the defendant's truck samples? A. Of the same order or magnitude.

Q. Well, now, go on to the next section of PX-166, referring to ferric iron and ferrous iron. A. Using different amounts of ferric iron varying from 300 parts per million to 1,000 parts per million, we found that the 300 parts per million gave a per cent reduction in corrosiveness of about one per cent; 440 parts, 3; 700 parts, 4; and 1,000 parts per million, approximately 4. In other words, the ferric iron had but very little effect in reducing the corrosive action. The ferrous iron in amounts from 300 parts per million to 1,000 parts per million had practically no effect in reducing the corrosiveness.

Q. And what is the difference between ferric iron and ferrous iron? A. Well, the ferric iron is one form of iron, a form of iron which, in solution, gives ions of a certain charge, and has a valence of 3, and the ferrous iron, in solution, has a somewhat different property. It is said to be di-valent, and has an electrical charge such that its valence is 2. The formula for ferric iron is FeCl_3 , and for ferrous iron is FeCl_2 .

The Court: I take it that there is no theory at all as to why 700 parts of the ferrous iron did give one per cent and the other didn't give anything even when you went up to 1,000? A. No, I have no explanation to offer of that.

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The next section of the Table we used copper and lead. In the next section, the amount of copper was kept constant at $3\frac{1}{2}$ parts per million, and the lead was varied from 10 to 1,000 parts per million. $3\frac{1}{2}$ parts per million of copper plus 10 parts per million of lead gave a reduction in corrosiveness of 36 per cent. $3\frac{1}{2}$ parts per million of copper and 40 parts per million of lead gave a reduction in corrosiveness of 38 per cent. $3\frac{1}{2}$ parts per million of copper and 160 of lead, 38 per cent; $3\frac{1}{2}$ of copper and 320 of lead, 38 per cent; $3\frac{1}{2}$ of copper and 420 of lead, 38 per cent; $3\frac{1}{2}$ of copper and 620 of lead, 40 per cent, and $3\frac{1}{2}$ of copper and 1,000 of lead, 41 per cent.

Mr. Owen: Now, it appears, then, that with the amount of copper constant at 3.5 parts per million the inhibitive effect of the addition of lead was the same whether you added 40 parts per million of lead or up to 420 parts per million of lead. A. That is right.

Q. Is there any explanation for that? A. Well, no simple explanation other than the 40 parts per million of lead seems to be a sufficient amount of lead to give practically a maximum effect with the $3\frac{1}{2}$ parts of copper.

Q. Then your table also shows the effect of small additions of ferric and ferrous iron to solutions containing 3.5 parts per million of copper. A. Yes, the addition of ferric iron gave but little effect. Adding 300 parts per million to the $3\frac{1}{2}$ parts of copper gave a per cent reduction in corrosiveness of 33%, which was the same as the 3.5 parts per million of copper alone. 440 parts gave but 34%, 700 parts 33% and 1,000 parts 34%, which means that the ferric iron had practically no effect on increasing the reduction in corrosiveness of the copper.

Q. And what was the effect of adding small portions of ferrous iron with the same amount of copper? A. They showed essentially the same type of result as the ferric iron; adding from 300 parts per million up to 1,000 parts per million of copper in the acid gave values of 34, 34, 33 and 34 per cent, which mean that the ferric iron was practically without effect.

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Q. In the next section of your table you have shown the effect of different combinations of copper and lead and of lead and iron with the lead kept constant at 420 parts per million. Please refer first to the portion showing combinations of copper and lead and give the results. A. When 1 part per million of copper was taken with these 420 parts per million of lead, about 30% reduction in corrosiveness was obtained. $3\frac{1}{2}$ p.p.m. gave 38%, 5 parts 40%, 10 parts 41%, 40 parts 42%, 80 parts 42%, 100 parts 43%. So that by adding increasing amounts of copper to the solution containing also lead of a constant amount very nearly maximum effects were obtained with the $3\frac{1}{2}$ parts per million of copper. From that point on increasing the amount of copper did not materially increase the per cent reduction in corrosiveness.

Q. Right in that connection, and in order to refresh the mind of the court, will you state approximately the average amount of copper and the average amount of lead found in the defendant's truck samples?

Mr. Lyon: Your Honor, it doesn't seem to me that these averages are anything but misleading. There is no such thing as an average infringement. We ought to have actual, if we are going to make determinations within two or three parts of a million, it seems to me we ought to have exact quantities compared. Averages just mix everything up in a scramble.

Mr. Owen: I will ask the witness to state the average amount of copper found in the Stella Wilcox samples, and the average amount found in the Zahn samples, and the average amount found in the Crawford samples, each separately? A. The average amount of copper found in the Stella Wilcox samples was 3.6 parts per million. The average amount found in the Zahn samples was 3.1 parts per million, and the average amount found in the Crawford samples was 4.8 parts per million. Now, taking an average of those three values: 3.6, 3.1, 4.8, would give 3.8.

Q. And, now, will you state the average amount of lead you found in the Stella Wilcox samples, and in the

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Zahn samples, and in the Crawford samples, stating each separately? A. The average amount of lead in the Stella Wilcox samples was 417 parts per million, in Zahn 437 parts per million and in Crawford 53 parts per million.

Q. So that in Crawford the copper was higher and the lead was lower than in the other samples? A. It was.

Q. Now, take each of the truck samples separately, that is, the average of the Stella Wilcox, the average of the Crawford, and the average of the Zahn, for copper and lead content, and point out which of the samples in PX-166 comes the closest to each one of those? A. Well, for the copper and lead in the Stella Wilcox the values are 3.6 and 417; turning now to my table, 3.5 is the closest value as to that 3.6, and 420 is the closest value I have to the 417, which means the solution numbered 27.

Q. And, what is the reduction in corrosiveness shown on your test of that combination? A. The reduction in corrosiveness is 38 per cent.

Q. Now, do the same with reference to the Zahn. A. For the Zahn, the parts per million of copper 3.1; parts per million of lead 435; and the closest I would have to that, apparently, is my No. 27 solution, showing 38 per cent reduction in corrosiveness?

Q. And now as to the Crawford? A. The Crawford, 4.8 and 53. That will be hard to get, that combination. The nearest for the copper alone would be 5, which is solution 37. The nearest to the lead alone would be 40, which is my No. 9 and would give a reduction in corrosiveness of 3 per cent, and 5 parts per million for copper, which is my solution No. 3, gave a reduction in corrosiveness of 37.

Mr. Owen: Doctor, I believe that you had gotten down to solution No. 45 on your table No. 18 (PX-166). Will you take it up from that point? A. Solution No. 45 is one containing lead and ferric iron in this proportion: 420 parts per million of lead, 300 parts per million of ferric iron, which is not far from the ratio found in some of the samples, and gave a per cent reduction in corrosiveness of 12. It was noted that keeping the amount of lead constant

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at 420 parts per million, and increasing the amount of ferric iron from 300 parts per million to 1000 parts per million, in steps of 300, 440, 700, and 1000, the per cent reduction in corrosiveness remained practically constant; in other words, increasing the amount of iron from 300 to 1000 parts per million had practically no effect on the reduction in corrosiveness. Referring to my solution No. 12 I find that 420 parts per million of lead alone gave a reduction in corrosiveness of 13 per cent. From that I should think it may be concluded that the addition of the iron had no effect on the solution.

Q. Now, taking up the next section, Solutions 49 to 52, where ferrous iron was added, what effect did that have?

A. Well, the data show that when the lead remained constant at 420 parts per million, and the ferrous salt was increased from 300 to 1000 parts per million, the reduction in corrosiveness did not increase. As a matter of fact, the figures show a very slight decrease in reduction in corrosiveness.

The Court: Let me see if I have the right idea out of that, doctor; that there is probably so much of that ferrous iron in the acid—my reasoning would be different all the way—it finally got so much it has kept the acid busy with that added ferrous iron— A. (interposing) It might be speculative that the solution already contains so much iron when 1000 parts per million were present that it tended to retard a bit the normal action of more iron to go into solution.

The Court: Tell me what it was corroding, again? What did you have for it to corrode on? A. The iron test pieces, one inch, by $\frac{7}{8}$ by $\frac{1}{8}$, for sixteen hours.

The Court: Well, it didn't corrode so much when you put in more of your ferrous iron, when you put in 1000 as it did when you had 700 in? A. It happened it did not get so much.

Mr. Owen: Now, Doctor, take up the next section, beginning with solution 53 and explain what it shows, from 53 to 59 solutions. A. In that section the experiments were conducted by adding to the pure acid a given amount

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of ferric iron—440 parts per million in each case, and the amount of copper was varied. The iron was kept constant in the different experiments and the copper was varied from one part per million up to 14 parts per million. In solution 53, containing 1 part per million of copper, 440 parts per million ferric iron the per cent in reduction of corrosiveness was 20. Solution 54 containing $3\frac{1}{2}$ parts per million of copper, 440 of iron, 34.

Q. And how do those compare with the results obtained from those two amounts of copper without any iron?

A. Very nearly the same. With the same amount of copper in the acid, $3\frac{1}{2}$ parts per million, the per cent reduction in corrosiveness was 33%, and in this case with the added 440 parts of iron it was but 34%, showing the iron had very little effect.

Q. Am I justified in stating from these tests that the presence of either ferric chloride or ferrous chloride in 15% hydrochloric acid solution has no effect on the rate of corrosion when there is also present small amounts of copper?

A. Well, apparently it has but very little if any effect.

Q. Now going to the last section of your table, you show combinations of copper, lead and ferric iron. Will you explain what those show? A. Well, in the first group of solutions from numbers 67 to 70 the copper and lead content is kept constant and the ferric iron content increased from 300 to 1000 parts per million, the copper and lead contents being 3.5 and 420 respectively. The effect of the increase in amount of ferric iron is at most but very slight for the results obtained are, for example, as follows: With 300 parts of ferric iron, the per cent reduction in corrosiveness, 39; with 440 parts, 40, with the 700 parts, 38; 1000 parts, 38; indicating that an increase in the amount of ferric iron when copper and lead are constant has but little effect and, if anything, gives a slightly lowered reduction in corrosiveness for the higher amounts of the iron.

The Court: Well, the adding of any of it doesn't seem to affect it, does it? I don't find much difference whether it is present or isn't present. A. The iron doesn't seem to make much difference.

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Mr. Owen: Well, you refer to solution No. 27 in which the same amount of copper and lead were present as in solutions 67 and 70, and the reduction in corrosiveness is 38 per cent, which is substantially that of the same solutions with ferric iron added.

The Court: The adding of the iron to the copper and lead doesn't seem to do much of anything.

Mr. Owen: Apparently not. Apparently doesn't have much effect.

The Court: You have a little difference, but you can hardly run through experiments and not have, I suppose, a trifle difference.

Mr. Owen: Now, the next group from 71 to 77, does that show anything different, Doctor, that you wish to mention? A. In that case the copper was kept constant at $3\frac{1}{2}$ parts per million and the ferric iron at 440 parts per million, while the lead was varied from 10 parts per million to 1,000 parts per million. I will refer to the results obtained in terms of the increasing amounts of lead. With 10 parts per million of lead present the reduction in corrosiveness was 34 per cent; with 40 parts, 37; 160 parts, 36; 320 parts, 37; 420 parts, 40; 620, 40; 1,000, 40. In other words, the maximum effects were obtained with about the 320 parts per million of lead, although as a matter of fact at 40 parts of lead it gave fully as high values. The maximum reduction in corrosiveness was obtained with 420 parts of lead, and increasing it from 420 to 1,000 didn't change the corrosive effect?

Q. What does the last section of these tests show? A. Why, in the last section are tests with ferric iron kept constant at 440 parts per million, the lead at 420 parts per million, and the copper varied from 1 part per million to 100 parts per million. The results show that with the 1 part per million of copper the reduction in corrosiveness was 30 per cent, with $3\frac{1}{2}$ parts per million, 40 per cent; 5 parts per million, 39 per cent; 10 parts per million, 41 per cent; 40 parts per million, 40 per cent; 80 parts per million, 42 per cent; 100 parts per million, 42 per cent.

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The Court: What does that show, the whole thing added together, more than that the copper from 1 part to a million up to copper at 5 parts to a million does the main trick, and the others don't do very much? A. I believe it does show that the greatest effect is obtained with the copper from 1 part to 5 parts per million, and that lead does contribute to the effect given by the copper somewhat.

The Court: Well, you haven't shown that the lead has done very much. 1 to 5 and I get clear up to 37. With 5 parts of copper alone I get 37. Now, where do you show anything—

Mr. Owen: (Interposing): I call your attention to solutions 23 to 29. That is the series which shows the effect of adding different amounts of lead to 3.5 copper.

The Court: But you don't get it higher than that, very much.

Mr. Owen: It shows at 10 parts of lead and 3.5 of copper, 36 per cent reduction in corrosiveness, and it goes up to 41 if you increase the lead up to 1,000.

The Court: Yes, but I know 3, $3\frac{1}{2}$ parts of copper to 100 parts, you see, takes it up to 38. Well, 5 parts of copper all alone takes it up to 37. And three and a half parts take you to 33.

Mr. Owen: Yes, the copper is the effective agent, there is no question about that.

Q. (Mr. Owen): Doctor, you have at the bottom of this table one test numbered 85. What is the purpose of that? A. Well, that test shows the effect of the presence of ferrous iron. The copper is present in the amount of 3.5; the lead, 420, and the ferrous iron, 440. The results could be compared with those obtained in solution 75, using ferric iron. With ferric iron, the per cent reduction of corrosiveness was 40; using ferrous iron, 39. It indicates that it makes but little difference whether the iron present is ferrous iron or ferric iron. Neither of them have much effect in reducing corrosiveness.

In all of these tests on my Table 18 (PX-166) I used 50 c.c. of the hydrochloric acid solution, at 85 degrees Fahrenheit with no agitation of the solution.

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I made other tests to show what effect agitation and increasing the percentage of the solution to the amount of exposed metal surface would have on the rate of corrosion. I made tests to cover both of these points, first, to determine the effect upon corrosion of agitating the solution during the test. In all of the results that I have reported so far, the solutions were not agitated; the metal strips were suspended in the solution, and the solution remained quiescent. I have prepared a table showing the results of those tests.

(The table was offered and received as PX-167.)

This table shows the results obtained when small pieces of strap iron of the size that we have just been discussing, the 1 inch by $\frac{7}{8}$ ths by $\frac{1}{8}$ th of strap iron, were tested for a period of 16 hours, at 85 degrees Fahrenheit, using as solutions the solutions given in the preceding table, my Table No. 18, Solution No. 2, for example in that table contained 15.1 per cent C. P. hydrochloric acid, $3\frac{1}{2}$ p.p.m. of copper and no lead or iron and gave with no agitation, as reported in the other table, 33 per cent. With agitation the value appears in the column following as 44 per cent. So, agitating that particular solution stepped up the reduction in corrosiveness from 33 per cent to 44 per cent. And, then, similar tests were made with some of the other solutions. Solution No. 26 containing, in addition to the acid, 3.5 parts per million of copper and 320 parts per million—

Mr. Lyon: What kind of agitation did you employ?

A. The agitation was brought about by placing my vessel containing a metal strip on the platform in a thermostat, and causing the platform to move back and forth, and the metal strip was supported by the small hole through the upper end which I referred to this morning with a glass hook. It was supported in such a way that the movement of the platform caused a swinging of the metal strip in the solution.

Mr. Lyon: Was the solution open to the atmosphere during the test? A. With a very small hole through the stopper which was placed over the vessel.

The Court: Was the liquid moved? A. The liquid

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moved somewhat, but the pieces of metal swinging in the liquid would cause, anyhow—it moved by being on a moving shelf which was kept at a constant temperature.

The Court: And, it would all move at that rate except that the suspended iron was free to swing as a result of this motion? A. Was free to swing; that is right, Your Honor.

The Court: There was nothing to move the iron except that its momentum as compared with the momentum of the thing that you moved? A. The platform, that is right, Your Honor. And, a number of tests were made simultaneously on this same platform, the different vessels were set up with these strips of iron and as the platform moved they all were agitated to the same extent, so that all of the results that I report in this table would be obtained with practically the same effect.

The Court: The container was agitated enough to stir or move the liquid within it as to itself and in addition there was movement of the iron through this agitated liquid. A. Well, the 50 cubic centimeters which was the amount of liquid we had in the container, would fill the container perhaps to the extent of a couple of inches, or so the metal strip was suspended down in that liquid. Now, the movement of the strip certainly would stir the liquid in the container and agitation would stir it some, but not as much as the movement of the strip would stir it.

The Court: Then in addition to agitating the liquid it caused a movement of the liquid past the surfaces of the iron? A. It did, yes.

The Court: How rapid was that, again? Like a malted milk shaker? A. It didn't go that fast. Perhaps a round trip of the platform per second, something like that.

Mr. Owen: Now, will you go on with your explanation, Doctor, please? A. Using solution No. 26, which contained $3\frac{1}{2}$ parts per million of copper, 320 parts per million of lead, no iron, gave without agitation a reduction in corrosiveness of 38%; with agitation, 48%. With the solution No. 30, the C. P. acid with the $3\frac{1}{2}$ parts per million of copper, no lead, 300 parts per million of ferric iron, with no agitation gave

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33% reduction in corrosiveness, and with agitation, 43%. The solution No. 34, with the C. P. acid 3.5 parts per million of copper, no lead, 300 parts per million of ferrous iron, with no agitation, 34% reduction in corrosiveness, and with agitation, 43%. Solution No. 68, in the C. P. acid, 3.5 parts per million copper, 420 of lead, 440 of ferric iron, it gave without agitation 40% reduction in corrosiveness, and with agitation 52%. Solution No. 85 contained besides the acid 3.5% parts per million of copper, 420 parts per million of lead, 440 parts per million ferrous iron, gave, without agitation, 39% and with agitation 50% reduction in corrosiveness.

Mr. Lyon: Doctor, these were percents of what? The same chemically pure? A. As I previously calculated. The percentages against blank acids.

Mr. Lyon: Were the blank acids agitated? A. Of a similar strength, yes.

Mr. Lyon: The blank chemically pure acids? A. Yes.

Mr. Lyon: You haven't any data here on that? A. I haven't data on that.

Mr. Lyon: Have you got it in your notes? A. I can get it for you. I can't say how soon. It is either here or at Ann Arbor.

Mr. Lyon: I would like to have it because you brought in the comparative data from which you calculated what was 100% in the case of the other tests, and I would like to see it in connection with these. A. I can furnish you with the data. If I don't have it typed, you will have to wait until I get it up here.

Mr. Lyon: Did you repeat any of your other work on agitation tests or just agitated these special samples made of C. P. acid with these particular parts of copper, lead and iron in them? A. As I recall, our tests are limited to these synthesized samples. I would want to leave the loophole to supply the information if by chance we were able to run the others. I don't recall that we did.

The Court: Have you any theory as to why agitation increased the reduction in corrosiveness? A. I think I probably have a theory which might account for it. It may

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be that the inhibiting agent can more readily get to the metal if the solution is agitated so as to bring a greater volume of the solution in contact with the work per unit of time. There is but a limited amount of the agent in contact with the surface. The agent must diffuse through the solution to get to the surface. Now, perhaps after the agent is rather depleted near the surface, the motion of the plate out into new liquid would bring it in contact with more of that—

The Court (interposing): Stronger. A. (continuing) —agent, which is present in small amount.

Mr. Lyon: What I don't understand, Doctor, is whether the blanks which represent the one hundred per cent against which you tabulate these percentages here, whether when they were agitated that increased the amount of corrosion or decreased the amount of corrosion in the blanks? A. Well, I will attempt to get you that data.

Mr. Lyon: Doctor, don't you remember whether it did or did not corrode more when you agitate the blanks? You have all the measurements. A. Just for the moment I haven't those figures in mind. I can refer to my data here. (Refers to data.) Your Honor, I think I can answer the question now, and I can furnish the data, if necessary. It just happened that the blank sample showed very little change in the rate of reaction but it was the inhibited sample that was slowed down by the agitation.

Mr. Owen: Will you make your answer a little more complete? You mean that the blank showed little change in the rate of corrosion under agitation from that when it was not agitated? A. When it wasn't agitated.

The Court: What about that blank you are talking about? You are talking about this chemically pure solution. A. Yes. With a chemically pure solution it just happened that the amount of action, corrosiveness, was practically the same whether the solution was agitated, as I have described, or not.

Mr. Owen: Which solution are you speaking of now?

A. With the C. P. Acid, and no added metal. We took one

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sample and permitted the vessel to remain without agitation for a period of sixteen hours, and measured the loss in weight of that metal. And another sample the same weight, same body of liquid, same temperature, agitated as I have described, for sixteen hours, and it showed a slightly lesser loss of weight than the one which was not agitated; showing that agitation, in that particular case, decreased the corrosiveness.

The Court: That is what I expected, and I still feel this shows it. Maybe not.

Mr. Owen: I think it does.

The Court: That would be just in accordance with this. In other words, when you add it in then you didn't eat quite so much? A. That is right.

The Court: When it was not inhibited? A. When it was not inhibited it reacted at about the same rate whether agitated or not.

The Court: Then the only surprise to me is, when there was not an inhibitor in, it did not have the same effect. That is a surprise to me.

Mr. Owen: I think perhaps the doctor can explain that, at least theoretically.

The Court: All right.

Mr. Owen: What is your theory on that, Doctor? A. Well, the explanation as to why the movement of the liquid, or, why agitation tended to favor inhibition, the explanation I made a few moments ago is that the inhibiting agent in this is present in small amounts, and perhaps the solution immediately adjacent to the metal becomes but slightly depleted; while agitation may bring the plate in contact with fresh solution containing a sufficient amount of the inhibiting agent so the action is more rapid and pronounced, perhaps.

Q. Now, proceed with your explanation of your Table XIX (PX-167). A. We carried out another set of experiments using the same kind of metal, same temperature, length of time, and so forth, and using the same kind of solutions just described in the last set of tests. We used

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a solution with a composition of our No. 2, for example, but instead of using 50 c.c. of the solution with agitation, we used 300 c.c. of solution.

The Court: But no more of the copper? A. The same amount of metal but instead of using 50 c.c. of the solution containing the $3\frac{1}{2}$ parts per million of copper, for example in solution No. 2, we used 300 c.c. containing $3\frac{1}{2}$ parts per million of copper.

The Court: You used six times as much solution but the same constituents of every kind? A. That is true, Your Honor.

The Court: And the only thing you didn't increase was the iron suspended. A. That is true.

Mr. Lyon: Your Honor, I would like to know if they figure the percentages against a new experiment with chemically pure acid with 300 c.c. or did they figure the 100% against this old blank they have used in here which only had 50 c.c. A. Naturally it was with the solution with the 300 c.c.

Mr. Lyon: You have no data on that? A. No.

Q. (Mr. Owen): Now, Doctor, continue. A. The results obtained in this case with the solution of C. P. acid containing $3\frac{1}{2}$ parts per million of copper, no lead, no iron, gave a reduction in corrosiveness of 63% when agitated; a corresponding solution of 50 c.c. had given a reduction in corrosiveness of 44%. Passing on to solution No. 26 containing $3\frac{1}{2}$ parts per million of copper, 320 parts per million of lead, it gave a reduction in corrosiveness with 300 c.c. of solution, agitated, of 63%. Solution No. 30 containing in addition to the acid $3\frac{1}{2}$ parts per million of copper, no lead, 300 parts ferric iron, gave with agitation a reduction in corrosiveness of 64%. Solution No. 34 with $3\frac{1}{2}$ parts per million of copper, no lead, 300 parts per million ferrous iron, gave a reduction in corrosiveness of 64%. Solution No. 68 in addition to the acid with $3\frac{1}{2}$ parts per million of copper, 420 of lead, 440 ferric iron, gave 63%. Solution No. 85, in addition to the acid, $3\frac{1}{2}$ parts per million of copper, 420 of lead, 440 ferrous iron, gave a reduction in corrosiveness of 65%.

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The Court: What do you suppose the result would have been if you had another column of 300 c.c. solution with no agitation? A. I would expect it to behave somewhat as the 50 c.c. solution with no agitation, giving perhaps a slightly lesser reduction in corrosiveness, but that is only a guess.

The Court: You wouldn't expect to get a reduction in corrosiveness, would you, if you had taken 300 c.c.? I mean a reduction from the first column. Take that 33, first No. 2 in the first column.

Witness: Of less than that?

The Court: Where we got 33, it would just increase that to? A. I would expect it to be considerably more. It is unfortunate we have not had an opportunity to run such series. I explained at the beginning of my session on the stand that I had to be conservative of the samples I had and I didn't have enough of the samples to enable me to make runs using as much as 300 c.c. solution.

The Court: I would think if it went either way it would reduce that.

Q. (Mr. Owen): I wish, doctor, you would bring with you either tomorrow or next week the data you have showing your tests of the blanks corresponding with the first and third columns of figures in your Table 19. Is that clear to you? A. That would be the first column, the one above the 33 per cent, and the third column, the one above the 63 per cent.

Mr. Lyon: I would like 44, too.

Mr. Owen: All right. If you made blanks for the others beginning at 44 bring those, also.

The Witness: I will be glad to bring such data as we have, and will attempt to get that assembled and in order.

Mr. Owen: Doctor, at the session yesterday you were mildly criticized for having taken averages of averages in connection with your Tables 1, 2, 3 and 4, which are PX-154 to 157, inclusive, and I asked you if you would make up those averages, omitting any reference to averages of minor portions of the tests. Do you understand what I

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mean? In other words, I want you to make up averages for those four charts or tables taking only the tests of the different truck acids. For instance, you have three Stella Wilcox No. 8 tests there. I want you to take those three figures under per cent loss in weight, and then I want you to go to the next sample, 12-B, Zahn, and take those three figures under per cent loss in weight, and so on down, and don't take any average of averages of the individual groups, but take one average of all of them. Take Table 1. The average would be of 2.02, 2.02, 1.98. Then you jump down to the third group, sample 12-B, and you take 1.80, 1.81, 1.81, and then you jump to the sample 5 of the Stella Wilcox and take 3.23, 3.30 and 3.22, and so on down, and when you get all those grouped take the average of them. Is that clear? A. I think I see what you mean now.

Mr. Owen: During yesterday's session, reference was made to the dates when the defendant purchased commercial hydrochloric acid, and placed it in its storage tanks, and counsel have agreed to stipulate that if Mr. J. J. Edwards were called to testify as a witness in this case, he would testify that he is manager of the Mt. Pleasant branch of the defendant in this case; and that he would further testify in accordance with the testimony given by him in his deposition taken in Mt. Pleasant on June 28, 1939, and I will read that portion of the deposition into this record. This is part of his direct examination.

(Reading): "Q. I asked you yesterday if you would bring data regarding the receipts of acid. Did you do that? A. Yes, sir. (Handing same to counsel).

"Q. What is it you have produced? A. Halliburton Oil Well Cementing Company monthly acid inventory."

This, of course, means the receipt of acid by the defendant company at its Mt. Pleasant station.

"Q. And what do these data sheets show? A. Show the district, the month ending . . . , the year, and show the date raw acid was received, gallons of, Baume, the dates that raw acid was sold, the ticket number, gallons and Baume, the balance on hand, gallons and Baume.

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"Q. Does it show the source of the acid? A. It shows from whom the raw acid was received and what was brought forward from the last report.

"Q. Will you please refer to data sheets you have produced and give the date on which each shipment of acid was received, the name and address of the company from whom it was received, the quantity received and the Baume? A. This does not list the address of the company from whom we received that.

"Q. Just give the name then, please? A. 4-23-38 we received from the Pennsylvania Salt Manufacturing Co., 3976 gallons 20 Baume acid (reading from the record).

"Q. Do you know the location of the plant from which that acid was shipped? A. I believe it was shipped from Wyandotte, Michigan. I am not positive of that. (Witness continuing): May 2nd, 1938, from Pennsylvania Salt Manufacturing Company, we received 3,914 gallons 20 Baume acid. May 3rd, 1938, from Pennsylvania Salt Manufacturing Company, we received 3,945 gallons 20 Baume acid. May 21st, 1938, from the General Chemical Company we received 6,075 gallons 20 Baume acid.

"Q. Do you know which General Chemical Company plant that was received from? A. I believe that came from Chicago.

"Q. And does that apply to all the later shipments from the General Chemical Company? A. I believe so. (Witness continuing): May 23rd, 1938, from the General Chemical Company we received 5,982 gallons of 20 Baume acid. June 15th, 1938, from the General Chemical Company we received 5,993 gallons of 20 Baume acid. June 15th, 1938, again we received from the General Chemical Company 7,824 gallons 20 Baume acid. July 24th, 1938, from the General Chemical Company we received 6,013 gallons 20 Baume acid."

And, interrupting his deposition there I will state that that appears to have been the last acid received prior to August 27th, 1938, when they received another carload from the General Chemical Company, and in the meantime the

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Stella Wilcox treatments and the Zahn treatments were made. And, continuing the deposition:

"August 27th, 1938, from the General Chemical Company we received 5,938 gallons 20 Baume acid. August 17th, 1938, from the General Chemical Company we received 7,866 gallons 20 Baume acid. And that is the last."

This deposition, Your Honor, was given on June 28th, 1938.

And, continuing:

"Q. Will you state approximately the gallon capacity of your storage tanks? A. Our storage tanks approximately are of 10,000 gallon capacity each.

"Q. Do I understand correctly you have received no hydrochloric acid since October 17, 1938? A. To the best of my knowledge that is right. We don't indicate one here. (Witness looked through tickets). Our inventory doesn't indicate we have received any acid since that time.

"Q. What amount of acid did you have on hand after you received that last shipment? A. After receiving the shipment on October 17th this brought our storage up to 26,695 gallons, 20 Baume acid.

"Q. How is that acid delivered to you? A. By tank car, railroad tank cars.

"Q. And what is your practice regarding the unloading of the acid when the cars are placed on your siding? A. We removed the connections at the top of the dome of the tank car and put, I believe it is an inch and a half rubber discharge hose, from the dome through the opening into our storage tanks. There is another connection on the dome that is hooked up with a small rubber hose running from an air compressor located in our building next to the tanks. The acid is forced from the tank car into our storage tanks by an air compressor.

"Q. Do you customarily remove the acids within a few hours when the tank car is delivered on your siding? A. Customarily."

Now, that ends the portion of the deposition which I wish to read.

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And, it is further stipulated that exhibits which were identified as Exhibits 1, 2 and 3 to the Edwards deposition may be received in evidence here as being photographs of the two storage tanks of the defendant company at Mt. Pleasant which have been referred to as the north and south storage tanks. There are two photographs of those tanks, Exhibit 1 shows them standing out very plainly, and Exhibit 2 is taken from a greater distance and a different position, and doesn't show them so clearly. Exhibit 3 to this deposition is a photograph of one of the defendant's truck trailers in which the acid is transported from the Halliburton storage tanks to the wells where the treatments are given, and in which truck tanks this lead plate arrangement, which has been described, is secured.

The Court: Do you want any exhibit numbers in this case? Now the next exhibit number is PX-168.

(The photographs above referred to were thereupon marked PX-168.)

By Mr. Lyon:

Q. Doctor, you can produce the data showing the tests, the blanks of the chemically pure acid using 50 c.c. and 300 c.c. referred to in connection with your testimony as to Table No. XIX? A. We have that data with us, but it will take some time—a few minutes to find it. I can get it for you today.

Q. Can you compile it and give it to us by Tuesday morning? A. We can give it to you Tuesday morning.

Q. The next item, Doctor, did you not make similar experiments with the plaintiff's commercial inhibited acid? I think the court asked you about that, and I understood you were going to produce that data? A. I don't recall that I have such samples.

Q. Well, do you remember whether or not you had any specimens of acid to which one to five per cent of any of the inhibitors named in the Grebe & Sanford patent in suit had been added, and did you determine the percentage of inhibition by the same method you reported for the defendant's? A. Yes, with the—

Mr. Owen: (Interposing) I will say in that connection,

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Your Honor, I have planned to offer proof of that kind this morning. We located it last night and are going to put it in.

Mr. Lyon: I would like to ask this question so we understand what this per cent inhibition means, Your Honor, in our studies of this matter over the week end. If the plaintiff's acid of the patent in suit containing one to five per cent of arsenic oxide shows that it is inhibited 99½ per cent as compared with the percentages that you have reported for the defendant's acid, that means, does it not, that the rate of corrosion of the defendant's acid is at least 100 times that of the plaintiff's own patented acid; is that not correct?

Mr. Owen: He is asking this witness to assume that the plaintiff's treating acid is 99.5 per cent inhibited, and if it is so inhibited, isn't this acid so many times more corrosive than the plaintiff's acid.

Mr. Lyon: I am trying to find out what this percentage means. What I am asking him is if the acid of the patent in suit, employing from 1 to 5 per cent arsenic oxide actually is inhibited 99½ per cent, if that, compared with the figure he has presented here as to the defendant's acid, does not mean that the defendant's acid is 100 times at least as corrosive as the acid of the patent in suit. I want to understand that. That will save us a lot of time.

The Court: I understand, for my purposes at least, that this is purely an arbitrary figure now.

Mr. Lyon: He has not produced a figure as to the plaintiff's acid.

Mr. Owen: The defendant's acid is not uniform. On some groups he gets a higher rate of inhibition than on others. If counsel wants to know the basis on which this computation may be made, I think he should take two arbitrary figures, one for theirs, and one for ours.

Mr. Lyon: I am willing that we should take for the defendant's acid, on the method of calculating that you have used in your tables, that the defendant's acid is inhibited 50 per cent, and that we should assume or take for

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the plaintiff's acid, the acid of the patent in suit, that it is inhibited 99½ per cent. That means, does it not, that the defendant's acid is 100 times as corrosive as the plaintiff's?

A. The question as asked, which is a hypothetical one, involves this, as I understand it, if the reduction in corrosiveness of one of the acids, referred to as the plaintiff's acid, was reduced to 99.5 per cent and if the corrosiveness of the defendant's acid was reduced in its corrosive action to 50 per cent, then it is quite obvious that the corrosive action of the defendant's acid is 100 times that of the plaintiff. That is correct.

Q. (Mr. Lyon): Now, were you not delivered samples for making corresponding tests from the Stella Wilcox well said to be taken on August 2nd?

Mr. Owen: That has been requested before, and the data is here, and I am going to examine the witness on it this morning.

The Court: Then they are going to answer that?

Mr. Lyon: Fine. Another point I would like to have you examine him on, if you intend to, if not I would like to arrange to get the data; did you examine the commercial acids and the defendant's well acid for the presence of anything except—and the defendant's tank acids, all three or any of them, for the presence of anything except copper, iron and lead? Did you examine them for arsenic or anything else? A. We did not for arsenic.

Q. Well, for anything else besides copper, lead and iron? A. As far as special analysis, no.

Q. Do you know whether commercial acid contains arsenic? If so, in what quantities? A. The ordinary commercial acids may contain traces, but not in any appreciable quantity, not in quantity to bring about inhibition to the extent that we have been discussing.

Q. Does it contain any arsenic ordinarily, commercial hydrochloric? A. We found none in making simple tests. By Mr. Owen:

Q. Doctor, you were asked this morning whether you had tested the Grebe and Sanford process, using an arsenic

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compound as inhibitor. I do not know whether counsel referred to the specific example of the patent or not—did you, Mr. Lyon?

Mr. Lyon: I would like to know what tests he made, using the arsenic chloride of between 1 and 5 per cent by weight in solution—the arsenic oxide.

By Mr. Owen: Did you make any tests using arsenic as the inhibitor in this Grebe and Sanford process? A. Yes, we did.

Q. What tests did you make in that connection? A. We made up a solution in accord with the stipulations of the patent taking the same relative quantities as are suggested in the patent, namely, for each five hundred gallons of 15 per cent acid—

Mr. Owen (Interposing): Let me read the statement from the patent. That is what the doctor is referring to. "For example, to 4500 pounds of a 15 per cent hydrochloric acid solution was added two gallons of arsenic acid solution containing 21 pounds of arsenic calculated at As_2O_5 ." Did you make up such a solution and test it? A. Yes. We made up a solution conforming exactly to those quantities, and tested it, and obtained a reduction in corrosiveness of 97 per cent.

Q. Now, do you have your notes on that test here? A. I haven't them in an assembled form. I simply have the data in some record I have here. Q. Read into the record what data you have. A. In my records here I have this notation. "Arsenic solution prepared according to the disclosure, Page 2, Line 74 and 78 of the Grebe-Sanford U. S. Patent No. 1877504, reduction in corrosiveness 97 per cent."

Q. Is that all you have here? A. That is all I happen to have here. I have other data available, but it is not with me.

Q. Will you bring it with you for the next session of the court? A. Yes.

Mr. Lyon: I would like to have it before, if we could have it Tuesday morning.

Mr. Owen: You mail a copy of it to defendant's counsel next Monday.

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The Court: I am putting this 97 down as a percentage of inhibition. That is right, isn't it?

Mr. Owen: That is right. That is correct.

Mr. Owen: Doctor, how many gallons is 4500 pounds of 15 per cent hydrochloric acid solution? A. Apparently it is about 500 gallons.

Q. And, in your tests of this patent example what proportion, or what amounts of acid and of arsenic did you use, if you have the data here? A. We have the summary, but we can remember the volume of solution used was 50 cubic centimeters.

Q. Do you know how long you ran it? A. The same as the other experiments, as I recall; the 16 hours at a temperature of 85 degrees.

The Court: If the other witness discovers at any time that his memory is different, it will be perfectly all right with me to interrupt.

Mr. Owen: I will ask Dr. Cardwell to speak up without hesitation.

The Court: He nodded, and I wanted to give my approval to that rather than—sometimes, you know, I give a witness fits for coaching, but here it is all right.

Mr. Lyon: But just to clear this up at that point, did you repeat any tests with agitation or with 300 c.c.'s of acid corresponding to the tests you made with the defendant's samples on Table 19? A. I don't remember that we did.

Dr. Cardwell: We did not.

Mr. Owen: Now, Doctor, mention has been made on two or three occasions of the samples taken at the first treatment of the Stella Wilcox well on August 2nd, 1938, three days before the treatment of the same well concerning which you have testified. I will ask you if you made tests of the defendant's acid taken from the defendant's truck at the first treatment of the Stella Wilcox well on August 2nd, 1938? A. I believe that material is referred to in my notes as Samples No. 1 and No. 2, and I did make tests of such material.

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Q. Will you refer to your notes and tell the court what tests you made and the results of those tests? A. Sample No. 1 gave a reduction in corrosiveness, with strap iron, of 82 per cent. Sample No. 2, with strap iron, gave a per cent reduction of corrosiveness of 84 per cent.

Q. Did you also test them with other irons? A. We did, with the National Supply Company iron, and the Oil Well Supply Company iron, and the Atha Supply Company iron.

Q. What were the results of those tests? A. With the National Supply Company iron, sample No. 1 gave a reduction in corrosiveness of 81 per cent. Sample No. 2 gave a reduction in corrosiveness of 78 per cent. With the Oil Well Supply Company iron—I shall read whole numbers here, I have the fractional parts of per cents which I shall omit, though,—sample No. 1, 73 per cent. Sample No. 2, 75 per cent. With the Atha Supply Company, sample No. 1, 88 per cent. Sample No. 2, 89 per cent reduction in corrosiveness.

Q. Did you analyze those samples, or either of them to see whether or not they contained copper, lead or iron, and, if so, what were the results? A. We did analyze each of them. Sample No. 1 contained 25 parts per million of copper; 270 parts per million of lead; and 480 parts per million of iron. Sample No. 2 contained 13 parts per million of copper; 250 parts per million of lead; and 480 parts per million of iron.

Q. I suppose the court would like to know, and I would like to have you state for the record, why you did not include the samples from this first Weber well, or, from this Weber treatment, in the tabulations which you have given showing the average corrosiveness of the defendant's treating acids on different pieces of iron? A. Probably,—there was one reason that we did not include that data in our first sets of tables. In the first place, the sample was quite different—I mean, the samples were quite different in appearance from the other samples; and they contained a surprisingly high percentage of copper; and, frankly, at

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the time we were very puzzled, and we did not quite see how those samples fitted into the picture, we did not know what might be wrong. We figured that the other samples did represent representative samples, and showed uniformly throughout, but,—well, it was for that reason, I think, that we failed to carry through samples 1 and 2 completely in our notes.

The Court: The samples of the acid are from— A. That is of the acid from the oil well.

Mr. Owen: Taken from the defendant's treatment at the Stella Wilcox well on August 2, 1938, three days before the other Stella Wilcox treatment of the same well.

The Court: Samples 1 and 2 were both taken from the same well and same transportation tank, at the same time?

Mr. Owen: Yes, Your Honor.

Mr. Owen: Doctor, did you find any other striking difference between this first Stella Wilcox sample and the other samples, that is, those taken from the second Stella Wilcox treatment, the Zahn and the Crawford treatments? A. Well, the one striking difference, the samples we received had a layer of oil on the samples, samples 1 and 2.

Q. How much oil, would you say? A. Oh, a very appreciable layer. I could tell by referring, probably, to original notes about the proportion of oil, but it was a very appreciable amount, a substantial layer of oil.

Mr. Owen: I will make an explanation at this point and support it by evidence so that Your Honor will keep up with the story. The evidence will show that when that first Stella Wilcox treatment was given the defendant first put in 500 gallons of acid into the well, and then the operator of the well asked him to make the treatment in four stages. There was 1000 gallons of acid. He asked him to make the treatment in four stages of 250 gallons each, so the defendant's truck man pumped back from the well 250 gallons of acid, pumped that back into the tank before these samples were taken, and, of course, in pumping it back into the tank it pumped a certain amount of oil along with it, and that was another reason why the Doctor

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thought it would not be fair to rely upon those samples which show a very much higher percentage of inhibition than the ones on which he has relied.

Mr. Lyon: To complete that explanation, Mr. Owen, this Michigan oil contains mercaptans, and if you had some Michigan oil in this acid or long pipe it would inhibit the acid, would it not?

Mr. Owen: I will say in response to that, Mr. Lyon, that you are perfectly free to use uninhibited hydrochloric acid as you buy it commercially in the Michigan oil wells, and if you can get inhibition sufficient to protect those wells due to the presence of the oil and the slight inhibitors, slight amount of inhibitor, there may be in the commercial acid, we won't complain.

Mr. Lyon: I am not asking for that. Just to complete the explanation, you say that the Doctor rejected that sample because it had some oil in it. As a matter of fact, that oil would increase the percentage of inhibition.

Mr. Owen: It would, yes.

Mr. Lyon: That is the point I am getting at.

Mr. Owen: And, that is the fact in every Michigan treatment made by the defendant, that in addition to the inhibitors that are present in its acid when it is put into the well, they have the benefit of this inherent inhibitor which happens to be in the Michigan oil. But, our contention is that that natural inhibitor in the oil is not sufficient for the defendant, or anyone else, to get by with uninhibited acid, and they don't attempt to get by with it.

Mr. Owen: Now, Doctor, I will ask you if you have a table showing the different amounts of copper, lead and iron which you found in defendant's storage acids and also in defendant's truck acids, the samples of which you examined? Have you one of those? A. Yes; I have such a table.

Mr. Owen: This table will be offered as PX 169.

(The table above referred to was thereupon marked PX-169.)

Mr. Owen: I might state, Your Honor, this is merely

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a convenient collection of this data so that you won't have to search through a dozen or more different exhibits to find it.

Q. (Mr. Owen): Now, doctor, will you explain what that exhibit shows? A. That exhibit shows the copper, lead and iron content contained in a thousand gallons of defendant's hydrochloric acid samples. The amounts are represented in terms of grams, and also there is represented on the chart the amounts expressed in terms of parts per million of the metal present in the solutions.

Q. In explaining that table, I suggest that you take up, first, the amount of copper in the storage samples and then the amounts of copper found in the truck samples. A. The amount of copper found in the storage acid sample N14B—that is with the storage acid diluted down to 14.5 acid to correspond to the truck sample acids—the amount of copper was 0.72 parts per million, or in each 1000 gallons of the acid solution the amount of copper was 3.1 grams. The same determination for the copper in the sample S14B, which is the south storage tank solution, diluted also to the same strength, was 0.69 parts per million or 3.0 grams in a thousand gallons. Now, the average copper content of the two storage tank acids was 3.05 grams per thousand gallons.

Q. Now, take up the corresponding truck acids. A. The corresponding truck acids are represented by Stella Wilcox sample in which the copper was present in 3.6 parts per million, or 15 grams per 1000 gallons, and in the Zahn acid sample of a corresponding strength, the copper was present 3.1 parts per million or 13 grams per thousand gallons.

Mr. Owen: Now, in this connection, I want to call Your Honor's attention to the fact that this Wilcox treatment and the Zahn treatment must have been made with the same storage acid because the data which I read in Mr. Edwards' deposition this morning indicates that no purchases of storage acid were made between July 24, 1938, and August 27, 1938.

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Q. Now, you take up the lead item for those, please.

A. The lead found in the storage acid sample N14B was 4.8 parts per million or 21 grams. In sample S14B 4 parts per million or 17 grams. The average of these two samples was 4.4 parts per million or 19 grams of lead in 1000 gallons of storage acid. In the corresponding truck acids, the Stella Wilcox sample had 417 parts per million or 1700 grams per 1000 gallons, and the Zahn acid 435 parts per million or 1800 grams of lead per thousand gallons.

Q. Now, take up the iron item. A. The iron content of the storage acid sample N14B, 13 parts per million or 56 grams; sample S14B 6 parts per million or 26 grams. The average of the two, 9.5 parts per million or 41 grams of iron per one thousand gallons of storage acid. While in the truck acids Stella Wilcox gave iron 473 parts per million or 1900 grams, and the Zahn well gave iron 380 parts per million, or 1500 grams per thousand gallons.

Mr. Owen: Now, before taking up the metal content of the N20B and S20B samples and the Crawford truck samples, I call attention to the fact that according to the testimony of Mr. Edwards, between the date when the Crawford well was treated and the date when the N-20 and S-20 samples were taken, there was one purchase of acid—7,866 gallons, from the General Chemical Company on October 17, 1938.

Q. Now, Doctor, take up these samples N20B and S20B, and the different metals in them, comparing them with the metals found in the Crawford sample? A. Storage acid sample N20B contained 0.17 parts per million of copper, or 0.75 grams. Sample S20B contained 0.26 parts per million, or 1.1 grams. The average of these two is 0.21 parts per million, or 0.92 grams.

The Court: Now, let me see, you are not claiming that these storage samples—you are not claiming that you have got a sample of the exact acid that they treated their well with?

Mr. Owen: No, Your Honor.

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The Court: But this shows how their samples ran?

Mr. Owen: That is right.

The Court: Is it the thought that I will draw the conclusion that if that is the way they were running, that is the way they probably were when they treated the well?

Mr. Owen: Yes, Your Honor.

The Court: All right. It is not any exact proof, but it is substantial, in other words.

Mr. Owen: We have shown in the testimony read this morning, of Mr. Edwards, that they had I think six or eight purchases prior to the date of the Crawford treatment all made from the same source, the General Chemical Company.

The Witness: The analysis of the Crawford sample showed a copper content of 4.8 parts per million, or 20 grams. The corresponding data for the other metal constituents of the acids is, the storage acid sample N20B contained 2.6 parts per million of lead, or 11 grams. The sample S20B contained 7.3 parts per million of lead, or 32 grams of lead. Or an average of lead content in these two samples of 5.0 parts per million, or 21 grams. It was found that the lead in the Crawford sample of corresponding acid strength was 53 parts per million, or 220 grams in 1000 gallons.

The analysis for iron showed that in sample N20B, there were 7.0 parts per million or 30 grams. In sample S20B, 9.6 parts per million, or 42 grams. This gives an average iron content of these two samples of 8.3 parts per million, or 36 grams. The iron analysis of the Crawford sample showed 210 parts per million, or 860 grams per 1000 gallons.

Mr. Owen: Now, just to give a resume of this showing on this chart PX-169, Your Honor, it showed that the metals in the acid used in the treatment of the Stella Wilcox well were increased over those found in the storage samples taken at approximately the same time in the following proportions—the Stella Wilcox truck acid had approximately 400 per cent more copper than the storage

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acid had; it had about 8,000 per cent more lead in the acid than the storage acid and 4,500 per cent more iron than the storage acid.

And the same data with reference to the Crawford well are that the truck acid contained approximately 2,000 per cent more copper than the storage acid contained; it contained approximately 1,000 per cent more lead than the storage acid; and approximately 2,300 per cent more iron than the storage acid. And those additions took place somewhere between the time when the storage acid was placed in the truck tank and the time when the treatments were made at the wells.

Now, yesterday we introduced quite a large number of charts which I know must have been more or less confusing and perhaps annoying to the court.

The Court: No; they helped me a lot.

Mr. Owen: But in order that the information with reference to the experiments made by Dr. Bartell, in which he added different proportions of metal in different combinations to fifteen per cent C. P. hydrochloric acid may be more accessible and intelligible, I have a chart which has accumulated that information and which I will offer as PX 170.

(The chart above referred to was thereupon marked PX-170.)

The Court: This shows corrosiveness and not inhibiteness.

Mr. Owen: Well, it shows both. The dark line shows corrosiveness. The upper line is for 15.1 C. P. hydrochloric, which is shown for purposes of comparison to be one hundred per cent corrosive. And then going ~~on~~ down it shows the relative corrosiveness of these different solutions with the different additions, and at the end of the chart—

The Court (interposing): The black lines show corrosiveness?

Mr. Owen: The black line is corrosiveness and the figure at the end of the line is the percentage of reduction of corrosiveness.

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The Court: Or inhibition.

Mr. Owen: Yes.

The Court: All right. The black line is the corrosiveness. That is what I first thought.

Mr. Owen: Now, will you explain this chart, Dr. Bartell? A. Black lines are placed on this chart on this scale to show the per cent corrosiveness of the different samples. Now, we have mentioned previously that with the C. P. acid the corrosiveness of that will always be taken as 100 per cent, and the C. P. acid is always used as a blank in making tests of the corrosiveness of other acid solutions. So that the first black line represents a hundred per cent corrosiveness of the C. P. acid. Now, the second line gives the corrosiveness of a solution of 15.1 per cent C. P. acid to which was added 440 parts per million of iron. The corrosiveness of that acid solution was 97 per cent that of the C. P. acid; or, the reduction in corrosiveness brought about by the 440 parts per million of iron in that acid was 3 per cent. These solutions to which I am referring on this chart are numbered. This is No. 16. That solution was referred to yesterday in my testimony in describing the corrosiveness of acid solutions to which have been added different amounts of metals.

Mr. Owen: That is PX-166, Your Honor, Table 18. In other words, the numbers 16, 11, and so forth, on this last chart just produced correspond with the solution numbers in the left-hand column of the chart in evidence as PX-166, Table 18.

The Witness: So, the first solution taken was No. 16 which I have just described, which showed a reduction in corrosiveness of 3 per cent.

The second test was that with solution No. 11 to which was added 320 parts per million of lead to the 15 per cent C. P. hydrochloric acid. That acid was 88 per cent as corrosive as the C. P. acid, or the reduction in corrosiveness was 12 per cent.

The next solution referred to is solution No. 2, to which had been added 3.5 parts per million of copper to

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the 15.1 per cent C. P. hydrochloric acid. The corrosiveness of that acid is 67 per cent that of the C. P. acid, or the reduction in corrosiveness is 33 per cent.

The next solution tested was solution No. 30 to which was added $3\frac{1}{2}$ parts per million of copper, plus 300 parts per million of iron. The reduction in corrosiveness in this case, again, was 33 per cent, showing that the 300 parts per million of iron added to the copper in this acid had practically no effect.

The next solution tested was solution No. 26. To the acid was added $3\frac{1}{2}$ parts per million of copper, 320 parts per million of lead. The reduction in corrosiveness in this case was 38 per cent.

Solution No. 68, to which was added $3\frac{1}{2}$ parts per million of copper, 420 parts per million of lead, 440 parts per million of iron—in that experiment the per cent reduction in corrosiveness was 40 per cent.

Now, in none of the samples mentioned so far was there any agitation. The solutions were of 50 c.c.'s in volume, and the metal pieces were as described yesterday, these small strips 1 inch by $\frac{7}{8}$ ths by $\frac{1}{8}$ th inch.

The next experiment represented on the chart is an experiment conducted by taking a solution the same as No. 2, containing $3\frac{1}{2}$ parts per million of copper, but agitated. It is 50 c.c. again, and agitated as we described previously. In that case, the corrosiveness was much reduced; it was reduced by 44 per cent.

Q. How does that compare with the same solution in which there was no agitation? A. The solution which was not agitated gave a reduction in corrosiveness of but 33 per cent; so the agitation resulted in an increased reduction in corrosiveness.

Q. Just proceed with your experiments? A. Another experiment was performed, using the composition of solution No. 2, but using 300 cubic centimeters of that solution. Also, the solution was agitated during the test. Otherwise the conditions were the same, that is, the length of time and the temperature. In this case, the corrosiveness was much

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less—the reduction of corrosiveness was greater, the reduction being 63 per cent.

Then another experiment was performed in which a solution indicated as solution No. 30 was used, 300 c.c. of that solution was used, and the solution was agitated. That solution contained $3\frac{1}{2}$ parts per million of copper, 300 parts per million of iron. The reduction in corrosiveness shown in that test was 64 per cent.

Now, there is one more test illustrated on this chart, solution No. 68, which we have previously used with a smaller volume of solution, and with no agitation, and we get here 40 per cent reduction in corrosiveness. The solution was one containing 3.5 parts per million of copper, 400 parts per million of lead, and 440 parts per million of iron. Using 300 c.c. of this solution, and agitating it gave a reduction in corrosiveness of 63 per cent.

The Court: It is my understanding that there is no new information given in this chart over that previously given, but that you have assembled out of the information previously given certain data that you thought would be helpful to me and to every one, indicating the picture of this? A. Yes, Your Honor, I believe that is correct.

The Court: You have selected from your previous exhibits all of this—in other words, the preparation of this did not require anything special? A. No, no new data.

Mr. Owen: It is based on the data contained in the previous exhibits. I thought this would be more convenient for you.

The Court: Yes, it is.

Mr. Owen: I have just one more matter, Your Honor. Last evening I asked Dr. Bartell to make a new computation of averages from his Tables I, II, III and IV, PX-154 to 157, inclusive. Have you done that, doctor? A. I have, yes.

Q. Can you tell the court the results and how you arrived at them? A. It was suggested that averages be calculated by taking a summation of all the direct data, as loss in weight for the different samples of acid used with a

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given piece of iron, taking the sum of all of those values, the per cent loss in weight; likewise to take the values obtained for corresponding blank acids. This was done. The summation of the per cent loss in weight for all of the oil well samples—I should say truck tank samples—were taken and then the summation of the corresponding blank samples weighed, so as to correspond in number to the truck tank samples, and then the total of these values were used and the reduction, per cent reduction in corrosiveness calculated from the summation of these two sets of values. By using that method, it was found that the average reduction in corrosiveness obtained with the metal strips of strap iron, as described in Table I, was 52 per cent.

Q. How did that compare with your previous figure made up in a different way? A. The values given yesterday, which was the average of the average values of the three oil well samples, was 53. So the values checked to within that extent, the calculation as suggested giving 52 and our method of calculation gives us 53, as the average of averages.

The Court: This latter one is really more accurate, is it not? A. No, Your Honor, I would not think it would be as justified, no.

The Court: Didn't you divide it by the—let's see now, you added all of the results and divided by the total here, the total number of experiments, is that it? A. We did, Your Honor, but it so happens that we had a larger number of samples for one of the oil wells than we did for the others, so, in my opinion, it was not quite as justified as the other method.

The Court: There was a larger—it was a truer average of your samples, but the way you had selected your samples, it made that unfair, doing it that way, and you take care of that unfairness by the first— A. (Interrupting): By the first method, yes.

The Court: In other words, if I was going to get the average weight of people in Detroit and Bay City, and I did not want to weigh them all, if I was going to go by samples,

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I ought to select them relatively—if there are 100 times more in Detroit than there are in Bay City, I ought to pick 100 more samples from Detroit than I would in Bay City?

A. That would be justified.

The Court: That is the theory that you used in taking care of this— A. (Interrupting): That is in effect the principle that I had in mind at first, since we had three samples from one well, and two samples from the other wells, and I took the average of the averages, yes.

(By Mr. Owen): Now, doing the same thing with your Table No. II, what was the result? A. Doing the same thing with Table No. II, the calculation made as suggested yesterday was 30 per cent; and the average of averages gave $31\frac{1}{2}$ per cent.

Q. Now, will you take up Table No. III and Table No. IV? A. Table No. III by the newer calculation gave 38 per cent, and the value that I gave yesterday was 38.5 per cent. Table No. IV gave by the more recent method of calculation 50 per cent; and by the method reported yesterday 51.5 per cent.

Q. My notes that I made on my copies of these charts yesterday do not correspond with the figures that you have just given for your average of averages. I do not know where the discrepancy is, whether I made a mistake, and I will have to change all of these. A. Let me check back on the chart and my notes. (After checking) Well, I am not certain yesterday but that there was brought in a third method of calculation, that the average of the seven samples was taken on.

Mr. Owen: I will ask you do this, Doctor. During the recess I wish you would ascertain what the original figures were you gave for these averages, and then we will put them in the record. A. That would be very simple. If I were sure which set of figures were given, it is perfectly possible to make either calculation.

The Court: All right.

Mr. Lyon: Frankly, Your Honor, I may be able to arrive at a point here before one o'clock where we can agree

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on what the issue is in infringement here, and dispose of any dispute as to the facts. I would like to do that because I would like to submit a clean cut issue to the court, if we could. That is what I am going to try to do. I have in mind what it ought to be, and if I can get an agreement on it, I would like to submit it. As I understand it, Your Honor, the plaintiff's charge of infringement in this case is based on increased amounts of copper and lead which they state they have found in the defendant's acid at the well as compared with the amounts that exist in the storage tank acid. Can we have an understanding to that effect?

Mr. Owen: The charge of infringement is based on the fact that the defendant's treating acids, which it uses in treating oil wells in this district to increase their productiveness, contain substantial portions of copper, lead and iron which they did not contain when those acids were purchased by the defendant, and as those acids stand in the defendant's storage tanks at Mt. Pleasant. And by "substantial amounts" I have reference to their effectiveness rather than to their quantity in grams or ounces.

Mr. Lyon: I think that answers my first question, Mr. Owen.

Mr. Owen: What we are interested in is the acid as it went into the well, and if that contained substantial amounts of inhibiting materials, that is what we claim to be an infringement, and I don't limit the charge of infringement to the portions of the inhibiting materials that were added or which accumulated in transit. I think we must take the acid as it is used in the wells and consider whether or not at that time it was inhibited acid within the meaning of this patent.

The Court: When it starts down?

Mr. Owen: When it starts down.

Mr. Lyon: As I understand it, those materials which you say are the added inhibitors are the copper, and the lead, and the iron which you find in the well acid which you didn't find in the tank acid. I just want to know if those are the inhibitors that you are charging to be an infringement.

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Mr. Owen: I wouldn't limit myself in such a way as to exclude other inhibitors that might be present. Those are the ones our expert found and we have shown that the amounts in which they were found are in themselves quite effective, but if the acids contain other inhibitors—

The Court (interposing): You haven't shown anything about the results they obtained in the well.

Mr. Owen: All we can do at this time is to show what the acids were that went into the wells, and how much they were inhibited as compared with C. P. acid.

Mr. Lyon: Can I put it this way: Do you claim now or contend that there is any other added inhibitor in the defendant's well acid other than these added amounts of copper, lead and iron?

Mr. Owen: I don't think we are so much concerned with whether they were added or not, as we are with whether they were present or not when the acid was used.

The Court: As I understand the question, do you claim there was anything present except this copper, lead and iron?

Mr. Owen: Apparently there were some minor inhibitors present in small amounts.

The Court: That you claim? You had it to analyze all these months.

Mr. Owen: Yes.

The Court: Why don't you analyze it and claim it, if there is anything more than that copper and lead and iron that I have heard about that is in there? You have had the samples there.

Mr. Owen: Well, I don't see that the burden is on the plaintiff to show every different thing that might be in that acid that caused it to be inhibited. I think the question is whether or not the acid is inhibited, and not how it is inhibited or what causes it to be.

The Court: But I have no reason to think it is inhibited by any result obtained by the thing down in the well. The only reason I have got to think it is inhibited is because it has got copper, lead and iron in it. That is the only thing in the world that makes me think it is inhibited.

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Mr. Owen: Well, you also have Dr. Bartell's tests, the results of his tests of the acid as it came from the defendant's truck tanks. Those were the first tests he made, and when he reached the conclusion that there were some things in that acid which caused it to be inhibited, then he made his analyses to find out what it was as far as he could, and he found that they did contain copper, lead and iron, and he has reported that data.

The Court: In other words, it is your contention that you could show it was inhibited and not bother what the cause of the inhibition was.

Mr. Owen: I think we could have done that.

The Court: You could put a piece of iron down in there and show it didn't eat it, and—

Mr. Owen (interposing): I think we could have done that, and it would be—the burden would then be on the defendants to show how the inhibitor got in there and what it was, and whether they were responsible.

The Court: As you claim the patent is so broad that it covers anything that inhibits.

Mr. Owen: That is true. Our patent is not limited to any specific type of inhibitor.

The Court: Or any particular type of metal.

Mr. Owen: No. No; that is true.

The Court: All right.

Mr. Lyon: I would like to go ahead.

Mr. Owen: It is confined to an inhibitor which will prevent corrosion of iron by hydrochloric acid.

The Court: He says he is satisfied with your answer.

CROSS EXAMINATION

Q. (By Mr. Lyon): Now, will you please refer to Exhibit 169, which is this summary of copper, lead and iron contained in grams per thousand gallons of defendant's hydrochloric acid samples, and convert those values into per cents so that we can compare them with the 1 to 5 per cent by weight called for in the specification of the patent in suit? A. Yes.

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Q. I do not care about the storage acids. That will take too long. Just take the truck acids and convert them into per cent, so that I can compare them with the statement commencing at line 86, page 1 of the patent, reading "1 to 5 per cent thereof, based upon the weight of the solution."

A. The values would be for the Stella Wilcox samples, 3.6 parts per million of copper, 0.00036 per cent. For the Zahn, 3.1 parts per million, would be 0.00031 per cent. For the lead in the Stella Wilcox, 0.04017 per cent. For the lead in the Zahn, 0.0435 per cent. For the iron in the Stella Wilcox, 0.0473 per cent. For the Zahn, 0.0380 per cent. And, the values for the Crawford would be; for copper, 0.00048 per cent; for the lead 0.0053 per cent; and for the iron, 0.0210 per cent.

Q. As I understand you, Dr. Bartell, you determined the per cent of inhibition for the specific formula appearing at page 2 of the patent in suit commencing at line 70 through to the end of the sentence on line 88, but in that test you employed no agitation; is that correct? A. That is correct.

Q. Now, it is reasonable to suppose, is it not, or you would expect that with agitation in that test you would get a higher percentage of inhibition than 97 per cent? A. We didn't perform the experiment. I would prefer not to speculate.

Q. With the defendant's samples where you had inhibitors present, you testified yesterday that agitation increased the percentage of inhibition. A. It did.

Q. Have you any reason to think that that wouldn't be true with the formula of the patent? A. I have no reason to base such an opinion.

Q. All right. Then the only thing we could do is compare the tests on the defendant's samples that had no agitation with the sample of the patent that had no agitation. I want you to tell me how many times as corrosive you found the defendant's samples to be than the specific sample of the patent formula, basing the comparison on the tests without agitation? A. It may take me a few moments to assemble the information.

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Q. I wish you would, because that is the effect of your testimony and I want to understand your testimony today, if I can, and see if we can shorten this proceeding. Of course, I want you to confine yourself to experiments with the same kind of metal as you employed in making the experiment from the formula of the patent in suit. A. We haven't available the data with which I can make an exact calculation that you have asked for.

Q. Why not? A. I have not the data with me obtained with the arsenic sample that was referred to.

Q. You gave me a figure of 97 per cent. A. I did.

Q. Inhibited, didn't you? A. That was the reduction in corrosiveness, but I haven't the experimental data from which that was calculated.

Q. What is it that you don't know? A. I do not know the original amount of weight of the metal, nor the loss of weight, nor the per cent loss in weight.

Q. I don't need that. Do you know what type of metal that experiment was made on? I mean I don't need it for this particular question? A. It was made with a metal similar to that that we have stated in the other experiments.

Q. Which one? You have a lot of different metals? A. Strap iron. But I do not know which series.

Q. You don't know which series? A. Of strap iron we used in that particular test.

Q. Your strap iron figure is shown in Table No. I, is it not? A. Some of them are, yes.

Q. Well, now,—well, all of them on Table No. I, Series D and B, are the only two on there, aren't they? A. That is right.

Q. And they all use strap iron. Now, then, you found that the Stella Wilcox—the samples from the Stella Wilcox well were—what is the difference between Series D and Series B? A. As I explained previously the series came from different lots or pieces of strap iron.

Q. All right. Well, let us compare it with Series D, in the first place. You say that these tests on Table I had no agitation? A. That is right.

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Q. All right. Now, we will compare your 97 per cent figure with your 47 per cent figure here, the first figure under the title, "Per Cent Reduction in Corrosion" in Series D. How many more times is defendant's acid as there shows corrosive than the patent sample which you say was 97 per cent inhibited? You divide 3 into 47, don't you? A. The corrosiveness of the plaintiff's sample would be represented by 3 into 53. The rate of corrosion of the one would be about 17 times that of the other.

Q. All right. Now, let us take the next value on that column 18, that is also 17, for all practical purposes, is it not? A. It would be close to that.

Q. 17 times. Now, let us go down to Series B on the Stella Wilcox well. On the basis of Series B how many more times corrosive is the defendant's well acid that was used on the Stella Wilcox well than the acid of the patent, the specific example from the patent you have given? A. Well, on that basis, it would be about 19.

Q. Sample 6 in Table I, the value 43 would also be approximately 19 times as corrosive? A. That would be 19 times, yes.

Q. And so would the average, then, without asking that. A. As a matter of fact, the one I gave before would be a little less than 19 in round numbers; it is close to 19.

Q. And so would the answer be from the sample from the Zahn well, which is value 42? A. In that neighborhood.

Mr. Lyon: Now, I would ask, Your Honor, is the plaintiff willing to concede, to stand on the results as shown from these tests, samples from the Stella Wilcox and the Zahn wells as typical and representing the results of the defendant's practice? And will it concede that the defendant's well acid is from 17 and 19 times as corrosive as an acid, or formula corresponding to that, commencing at line 74 through the sentence ending at line 79, on page 2 of the patent in suit?

Mr. Owen: We will not make such a concession for the reason that these tests made by Dr. Bartell are laboratory tests which were conducted for the purpose of showing how

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much the defendant's acid corroded the iron in laboratory tests as against commercially pure acid. Now I think Your Honor appreciates that plaintiff is in rather a difficult situation here because we cannot go out and buy an oil well and bring it in here and have it acidized before the court and take that pipe before and after treatment to show the effect of the treatment. We will show, I will state to the court and counsel, by other witnesses, that we have done the next best thing—that we have conducted large scale laboratory tests, but instead of using 50 c.c. or 300 c.c. of acid solutions we have used about 200 gallons of solution. And we have run that solution through an oil well pipe. We have run a series of those tests, both with acids—hydrochloric acid to which these metals have been added in proportions found by Dr. Bartell—and acids which have been produced in a tank built in accordance with the description of defendant's truck tanks, which is in evidence. Those practical tests, as nearly practical tests as we are able to make, show a lower rate of corrosion for the synthetic acids made up to correspond as nearly as possible with the defendant's treating acids; they show a much lower rate of corrosion than resulted from Dr. Bartell's tests. So that I do not want to have counsel proceed or the court to proceed on the theory we are standing alone on Dr. Bartell's tests. Of course it is a simple matter of computation. Counsel doesn't need to fill the record with these computations. Your Honor can make them in your head. It isn't to show one acid is 19 times as corrosive as the other—

Mr. Lyon (Interrupting): I think it is the point.

Mr. Wiles: There is another element counsel has entirely overlooked, and I refer to that part of the specification which has our preferred example, which approaches, at least, one of the best of the inhibitors, but we name a considerable number of other inhibitors as being within the invention, and the use of those will show, and Your Honor will see that the plain intent was to cover inhibitors that are not as effective as the preferred one given, but which materially benefit conditions when you have the acid on iron.

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Mr. Lyon: I will have something to say about that when we come to the argument. I am trying now to get the facts before the court.

Mr. Wiles: We are not going to stand on any specific example in the patent, where the patent names a considerable number that differ among themselves.

Mr. Lyon: Dr. Bartell, what per cent by weight of the solution of As_2O_5 is there in the specific example that I have referred to on page 2 of the patent in suit, commencing at line 74? A. (After figuring and conferring with Dr. Cardwell): The best that one can do with that is, of course, an approximate calculation, because to the 4500 pounds of the 15 per cent acid is added 2 gallons of arsenic acid, which changes the thing a little bit, but it would be in the neighborhood of about four tenths of one per cent.

Q. In other words, as far as the range of one to five per cent at line 86 on page 1 of the patent, that formula is a minimum quantity and not a maximum quantity; that is obvious, is it not? A. It is not obvious as to what is meant by the question. If the question simply is to ask whether .4 per cent is closer to 1 per cent than to 5 per cent, the answer is obvious.

Q. Yes. All right, now, referring to the tests with the Detroit company acid, which you stated was 15 per cent inhibited, in the case of strap iron without agitation, how many times as corrosive is that acid than the formula we have just referred to in the patent in suit commencing at line 73 on page 2? A. As I understand the question, the answer obviously is that if the Detroit acid is 15 per cent inhibited it is 85 per cent as active as the C. P. acid, and I understand that the solution referred to as covered by the description of the patent is the one which we reported as giving a reduction in corrosiveness of 97 per cent. Hence that acid would show a corrosiveness of 3 per cent that of the C. P. acid. So, on that basis, the acid showing 85 per cent corrosion would be about 28 times as active as one showing 3 per cent corrosion.

Q. Now, as I understand you, the plaintiff did not

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furnish you with a specimen of its inhibited acid that it employs commercially under the patent in suit, and you have made no tests of any such specimen; is that correct?

A. I have made no tests of the plaintiff's acid.

Q. Well, I show you a copy of the plaintiff's publication entitled, "The Acidizer" for April, 1939, "Importance of addition agents in acidizing," and call your attention to the table, "Comparative value of inhibitors," appearing on page 2, together with the statement "Per cent of effectiveness of several ordinary inhibitors for prevention of corrosion of steel as compared with 99 per cent results obtained from the use of Dowell's inhibitor." Now, on the basis that the plaintiff's acid of the patent in suit is inhibited to the extent of 99 per cent, then comparing that with the 47 per cent that you referred to in connection with the defendant's acid from the Zahn and Stella Wilcox wells, the defendant's acid is 53 times as corrosive as the plaintiff's acid, is that not correct? A. The answer to the question as to whether an acid which would show a corrosiveness effect of 53 per cent and another which would show an inhibition of 99, or a corrosiveness of 1 per cent, it is true that the one showing the 53 per cent corrosiveness would be 53 times as active.

Q. Now, you have produced Tables No. I, II, III, IV, VII, VIII, IX, XII, XIII, XIV, XV, XVI—no, or up to XIX, here, which appear to me to be all printed here, and all in order at present, but there seems to be missing Tables V, VI, IX, X, VII and XVIII. I want you to tell me what those other tables are? Do you have copies? A. No, I haven't.

Q. Well, you better tell us what they are first. Doctor, you have found those copies? A. I have found all but one of my tables.

Q. Tell us what they are. Tell us what missing table V is, and what missing table VI is, and so forth? A. I will, as far as I am able to here. Missing table V was simply a summarizing table, giving a summary of the per cent reduction in corrosiveness of table I, II, III, and IV;

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and it contained that summary of results with the data obtained with the samples from the three—the truck acids from the three wells, and with the four metal pipes. It was simply a summarizing table.

Q. What about table No. VI? A. Table No. VI was a table with but four entries, and that table gave the percentage composition of the concentrated hydrochloric acid found in the storage tanks, samples N-14-B, N-20-B and S-14-B and S-20-B, together with the average of those concentrations.

Q. What about Table No. IX? A. Table No. IX is another summarizing table. It gives a summary in the reduction of corrosiveness, tests made with the storage tank acids, together with the calculation of the average reduction of corrosiveness for those samples.

Q. And table No. X? A. I am uncertain about my table No. X. The position I have here for No. X is the table I presented with the percentage of reduction in corrosiveness of five commercial hydrochloric acids, the values, the figures that I read into the testimony the other day; but I am not certain that that was the original No. X. In fact, I doubt it. I would like to check back on that.

Q. Now, what about No. XVII? A. XVII was a table I had compiled giving data of the analysis that we made of the samples of Mt. Pleasant water, taken on different dates, and it gave the copper analysis of the water on those six different dates.

Q. Now as I understand it we now have before us all the tests that you made?

The Court: No. X, he doesn't know.

Mr. Lyon: He says he thinks it is the percentage of inhibition of commercial hydrochloric acid. A. I am quite certain it had to do with inhibition. I would like the opportunity to place the proper table there if I can locate it. It apparently hasn't been in my notes since I have been on the stand. I thought my tables were complete when I came on the stand.

Q. When we get No. X now, we will have had reported

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here the results of all the work you did on this subject, is that correct? A. Oh, I wouldn't say that is entirely correct. I certainly have done some work that may or may not show up in these particular tables. That would be a pretty broad statement to make.

Q. Have you done any experiments on any of these subjects of any significance in connection with the matters that you have reported here which haven't been presented?

A. I believe I am correct in stating that this would represent all of the significant work. I believe it would. I say that with reservation. I may have overlooked something but if I have, I don't recall what it would be, with the possible exception of what may appear on that table X.

Q. Now, you did not determine what effect agitation would have on increasing the percentage of inhibition which you reported for the commercial acids, did you? Commercial raw acids? A. No, we did not have that data.

Q. You didn't determine what effect conducting the experiment with 300 c.c. of acid instead of 50 c.c. of acid would have on the percentages of inhibition that you reported to the commercial raw acids, did you? A. No, I don't think I did.

Q. Your answers to those two questions would be the same as to the samples of defendant's storage acids? A. That is true of both the defendant's storage acids and tank acids.

Q. Now, Doctor, can you tell us the date you did the work which is reflected on the table No. I, the date of the experiment? I wish you would take each one of these tables and give us the date the work was done by you and your associate. A. That is asking for a pretty large order. We will be glad to do it. I couldn't do it without referring to my notes.

Q. Has any of this work been done recently? Any of the work reported in your testimony? A. Yes. Some.

Q. When was the most recent work? A. Work I reported on the agitation.

Q. When was that done? A. Oh, that was done within recent weeks.

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Q. How long ago? A. I would have to check to give you the exact dates. Some of it within, I believe, the last three weeks.

Q. Now, these tests you made with the samples from the Crawford well, and the amount of or the per cent of inhibition which you report is more than could be the result of the presence of the copper and lead and iron which you have reported for those samples; isn't that correct?

A. I don't know that I have made an analysis of the result from that standpoint.

Q. Well, now, wait a minute. You put a table in here showing that after you got up to a certain point that added amounts of copper or added amounts of lead did not materially affect or increase the inhibition? A. That was with chemically pure acid, yes.

Q. You didn't make these various comparisons as against commercial acids? You made them as against chemically pure acid? A. We used chemically pure acid; yes.

Q. Well, now, you don't think that those results are valid for what the differences in the amount of inhibition and the percentage of inhibition there will be between commercial acids and inhibited acids, as distinguished from chemically pure acid? A. The commercial acid may contain certain impurities which might have a somewhat different effect upon the tests.

Q. Well, can you definitely state in the case of these Zahn and Stella Wilcox samples what part of the percentage of inhibition which you report is in excess of the inhibition that was had by the storage acids from which the well acids or tank acids were derived? Can you state that definitely? A. My answer to that is simply reference to the testimony I have given, obtaining or taking samples of the storage acid, actually making tests with that acid, then actually making tests with the Zahn well acids, gives the comparison to be obtained between the two.

Q. How many tests did you make with the samples of the storage acid to determine the per cent inhibition of

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that storage acid? A. Well, we made at least one in every case. Not always as many as in the other case, for the simple reason that we did not have the volume of acid to work with.

Q. I notice, Doctor, that in some of these cases you compare the results of one test with an average of the results of three or four tests? A. Yes.

Q. Now, that is not valid; if the result of the one test is approximately the result of one of the series of tests that you are going to average—that is true, is it not? I will try to pick one out here. Let us look at PX-159. A. Yes, sir.

Q. You report as the average per cent loss in weight, with six trials, with commercially pure hydrochloric acid, a value of 2.53, do you not? A. With the chemically pure hydrochloric acid, yes; we used the data obtained with six different tests.

Q. And one of those individual tests has a value of 2.44, has it not? A. It has, per cent loss in weight, yes, sir.

Q. Will you look at the next item above it, that individual test you made on Sample S-14-B has a value of 2.43, has it not? A. It has, yes, sir.

Q. You report that the relation between the sample S-14-B and the chemically pure hydrochloric acid shows a value of what? Of 4.0, do you not? A. That is right, yes, sir.

Q. Well, there is no such difference between 2.43 and 2.44, is there? A. No, but it must be pointed out that all of the data we had for the S-14-B sample gave a value of 2.43, while we were able to take the average of the number of tests made with the chemically pure acid, and the average value in that case was 2.53.

Q. How do you know that a single experiment that reports a value of 2.43 is not in a relation corresponding to the value of 2.44, one of the tests with the chemically pure acid? A. Throughout we have taken the best data that we could obtain under the conditions, and have made the calculations accordingly. We have presented the data,

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that this represents the results with one sample, and we feel justified to use the figures in the calculation.

Q. Now, I want to know within what per cent of accuracy we can accept this work, if it is based on that kind of relations. If you are going to take one value for one acid and six values for another, and derive a percentage, you can't say that is accurate work. A. Our six values certainly shows we did no choosing there to obtain the best values.

Q. I am not accusing you of anything. A. And all we can say about the other is that it was the best value we could obtain under the conditions with the amount of solution we had.

Q. Isn't it just as logical to say that if you could find a sample of the S-14-B acid test that came out 2.14 and a test with the C. P. acid 2.44 that those are the comparisons that should be made rather than add five more of one and none of the other in the form of tests? A. That would not be my opinion. I see no reason why one with a series of data should pick from that series of data some one value that just happened to fit a situation.

Q. In many instances in this work you have used,—you have compared the value of an individual experiment for one material with an average of the values of chemically pure hydrochloric acid tests? A. Not in many places in our work, no.

Q. If you are going to compare one average with another you should have the same number of tests in each of the series that you are averaging, should you not? A. It is well to when one can.

Q. Well, what about on this same sheet, PX-159; you averaged two tests of sample N-20, two tests of sample S-20, and how many tests of hydrochloric acid? A. Well, it just happens there that nine are reported. It happened that many values were available.

Q. Now, in the results that you depend on for your reports and for your calculations are loss in weight per grams of the samples of metal that were suspended in the

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various acid solutions, is that correct? A. Loss in weight calculated in grams, yes.

Q. That means you weighed the specimens of metal before and after the experiments? A. That is right.

Q. And if we attribute this reduction in corrosiveness to the action of copper and lead on the assumption that you made yesterday that copper and lead in its inhibiting action would, to some extent, plate out or form a protective coating on the specimen in the metal, would it not? A. Some of the copper and probably some of the lead would tend to deposit on the metal.

Q. Whatever amount of such copper or lead did so deposit would increase the weight of the sample when you weighed it, and increase the apparent reduction in corrosiveness, would it not? Unless you corrected for it? A. But the difference in weight due to such a coating would be exceedingly slight for a given piece of metal, such as the size we used.

Q. Oh, well, did you measure it to determine how much it would be and make a correction for it? A. I haven't made any calculation.

Q. Did you make any correction for it? A. We made no correction for it.

Q. Well, we are dealing here with very small quantities, are we not, in these tests? A. We did go so far as to make this calculation, if I may amplify the answer, that weighing out to the fourth place as we did, the amount of copper or lead would not be detected.

Q. How do you know? A. Well, we know that from the amount of copper we had in solution, for example, and the change in concentration that might have occurred in the solution, that there is not enough copper plating out to be weighable on a piece of that size.

The Court: That is, I thought, if I got the meat of your question, the deposit of lead on there would be just as important in the matter as a deposit of copper.

Mr. Lyon: That is correct.

The Court: I understood the answer to say that the amount of copper would be very small. What about the

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lead? A. Such lead as might deposit would not be detected in the weighing to the accuracy of these weights.

Q. How do you know if you haven't tried? A. Well, that is simple enough to make a calculation. Do you have any evidence on that (addressing Dr. Cardwell)?

Dr. Cardwell: You know how much copper there is in the solution, and we know that is beyond the fourth place.

A. Yes; even the total amount there.

Dr. Cardwell: If you plated it all you couldn't weigh it.

Mr. Lyon: I believe you attribute or are willing to attribute the greater reduction in per cent—per cent reduction in corrosiveness of the samples from the Stella Wilcox on August 2nd to the presence of oil in the samples that were delivered to you; is that correct? A. Those are the samples I mentioned this morning?

Q. Yes, I think so, Doctor? A. No, I am not ready to make that admission. I do not know for certain why the bigger difference in the two samples occurred.

Q. Did you analyze that material to see or make any test to determine if it was contaminated with an oil and whether that oil had any inhibiting effect on the acid? A. I don't recall the tests I may have made on that at the time. I don't recall that we had data on that. I do remember that at the time we stopped work temporarily with that sample, and whether we went back to it I don't recall.

Q. Did you make any tests on samples from the Zahn and the Stella Wilcox wells, the other samples, or from the Crawford well, to determine whether or not they were contaminated in any way or with any oil? A. I don't recall that we did.

Q. Based on all results of your work and all that you know about the subject, in your opinion did the well samples from the Stella Wilcox well which you refer to as your sample No. 8, or the well samples from the Zahn well, which you refer to as your Sample 12B, or your sample 5 from the Stella Wilcox well, your sample 6 from the Stella Wilcox well, or your sample 12 from the Zahn well, contain any inhibitor other than the amounts of copper, lead and iron

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which you have reported that you didn't find in the storage samples N14B and S14B, N20B and S20B? A. I wouldn't be able to answer that question without very careful study of the figures.

Q. Have you made such a study? A. I don't know that I have made a study that would answer specifically the question you have asked. The question is long enough so I am just a little bit uncertain as to the entire scope of the question.

Mr. Lyon: Well, let's leave that question unanswered until we resume here, and in the meantime you may be able to prepare the answer to it if you will.

Q. The per cent of reduction in corrosiveness you reported for the Crawford well is higher than you could account for because of the presence of the amounts of copper, lead and iron, is that correct? A. I believe it was.

Q. But you have no suggestion as to what it was in those samples that produced that greater percentage reduction in corrosiveness? A. Well, apparently, there is some constituent present other than the metals that gives the greater percentage reduction in corrosiveness.

Q. Did you attempt to determine what that is? A. And I have made no attempt to determine what that might be.

The Court: Well, is oil an inhibitor? A. It has been suggested here, I think by counsel for the defense, that oils do contain certain sulphurous compounds that might have that effect, and, if that is true, I would not want to rule out the possibility of such a constituent being present in the oil.

The Court: That is, oil as oil? A. Oil as oil, but the pure oil I would not expect to have an inhibiting effect.

Mr. Lyon: I call your attention to line 3, page 2 of the patent in suit, Grebe and Sanford, 1,877,504, one of the inhibitors there specifically mentioned is mercaptans, is it not? A. Yes, sir, it does.

Q. That is a sulphur compound? A. That is a sulphur compound, yes, sir.

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Q. It is well known that Michigan oils are especially rich, if you want to use the word "rich," in mercaptans?

A. I would not say that it is well known, because I did not happen to know it myself, and if that is true I really should have known it, but they may contain mercaptans.

Q. Mercaptans have a very distinctive odor, do they not? A. They do.

Q. Do you know whether they have a pretty distinctive odor that corresponds to the odor of mercaptans?

A. I know that some of the oils have a reasonably pungent odor, but I have never happened to associate it with mercaptans.

Mr. Owen: The witness has found Table X, which was referred to on Saturday, and which relates to the tests that he made with other inhibitors mentioned in the Grebe and Sanford patent. I think the mixup on Saturday came about by reason of the fact that his Table X was confined to his use of 1 per cent of the inhibitor; and I learned that he had made tests with higher proportions, and I wanted him to revise the table, so as to include the higher proportions.

We have both tables here which I will ask the witness to produce, first the original one, and then the revised table.

Mr. Owen: The witness has produced his original Table X, which I will offer as PX-171.

(The table above referred to was thereupon marked PX-171.)

Mr. Owen: Will you explain this table PX-171? A. Table PX-171 contains results on percentage reduction in corrosiveness when some of the materials referred to in the Grebe-Sanford patent were used. The results were obtained using strap iron, of pieces the same size as have previously been described, 1 by $\frac{7}{8}$ ths by $\frac{1}{16}$ th inches, in acid solutions of 50 cubic centimeters, and the tests were run for the period of 16 hours. The materials reported in that table are a saturated solution of acridine in 15.1 per cent hydrochloric acid, which gave a reduction in corrosiveness of 41 per cent. 1 per cent solution of aniline in 15.1 per cent

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hydrochloric acid gave a reduction in corrosiveness of 34 per cent. A 1 per cent solution of pyridine in 15.1 per cent hydrochloric acid gave a reduction in corrosiveness of 47 per cent. A 1 per cent solution of quinoline with the same concentration of acid gave a reduction in corrosiveness of 84 per cent.

Q. Now, those tests were without agitation, as I understand. A. Those tests were without agitation.

Q. Now, did you make tests of any of these inhibitors using more than the amounts you used in the tests shown in Table X. A. I did.

Q. Will you state what those tests showed, and whether or not you made them at the same time you made the tests in Table X? A. The solutions of three and five per cent which were run were run a few days later than with one per cent solution.

Q. What were the dates? A. Let's see. That is about a year ago.

Q. Now, will you state the results of your tests using higher proportions of inhibitors? A. Using three per cent aniline—

The Court (interposing): Have you got those in a table? A. I have not, Your Honor. I have them simply in my own notes.

Mr. Owen: In the tests shown in this PX-171, the witness used saturated solutions in the case of acridine and a one per cent solution in the case of aniline. That is, he added one per cent of aniline to the fifteen per cent hydrochloric acid, so that the solution contained, the entire solution contained one per cent of aniline and ninety-nine per cent of the acid. Now, the new tests that I am going to ask him about were the same as those shown in the exhibit except that instead of using one per cent of aniline he used three per cent, and I believe also one with five per cent, and the same is true with respect to the pyridine and the quinoline. He did not change the hydrochloric acid solution strength, but he did increase the percentage of inhibitor placed in that solution. Is that clear?

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The Court: Yes.

Mr. Owen: Now, will you go on with your answer, Doctor? A. The three per cent solution of aniline in the hydrochloric acid gave a reduction in corrosiveness of 60 per cent.

Mr. Owen: I think I will ask the Doctor to re-tabulate this exhibit PX-171 and to add these.

The Court: If there is going to be only a couple, and nobody has objection, I will just add it right down below in pencil.

Mr. Owen: All right.

The Court: Three per cent. That is what?

Mr. Owen: Reduction in corrosiveness of 60 per cent.

Q. Then with 5% of aniline, what was the result? A. The value was 67% reduction in corrosiveness.

Q. Now, as to the pyridine, did you make other tests with that? A. I did. With the 3% solution of pyridine the reduction in corrosiveness was 60%. And with the 5% solution the reduction in corrosiveness was 65%.

Q. Now as to the quinoline? A. With the quinoline, the 3% solution gave a reduction in corrosiveness of 84%, and the 5% solution a reduction in corrosiveness of 84%. The different concentrations of quinoline gave practically the same value in reduction of corrosiveness.

Q. Referring now to the five commercial acids which you purchased and tested, do you recall when you purchased those acids? A. It was approximately in June of '39. It was close to June of '39.

Q. And what did you order? A. I ordered from each of the companies which have been mentioned, a gallon of their commercial acid.

Mr. Owen: Now, during Saturday's session the court asked for the dates of the different samples.

The Court: If I remember my own mind—I recognized it was all in the record—what I was suggesting was that somebody that had time make a little tabulation of something that I could put my eyes on. You talked about analyzing these different things. Something I could put my eyes on so I can place them properly in the picture.

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Mr. Owen: We will be glad to do that.

The Court: All right.

Mr. Owen: I think it might be convenient if we prepared a tabulation showing the dates when the defendant replenished its storage tanks and the dates when these well treatments were made, and the dates when the storage samples were taken.

The Court: And the samples taken out of the transportation tank.

Mr. Owen: Yes. We will do that.

The Court: I dare say it is in the record that we had in mind to get. This other was just an added thought. Now, you have got it all in the record, but I doubt if any of you could exhibit to me right now, although in the record, and if you could I would have it this afternoon if I wanted to look at that, and have it in mind. I would just like to see on one page a picture of what we are talking about.

Mr. Owen: We will do that.

Mr. Owen: Do you wish to make a correction as to the date when you performed those experiments that you were just testifying about? A. Yes, I would like to. The question was asked as to the date that these experiments were performed, and in checking carefully I find that they were all performed the latter part of June or the first of July, 1941.

The Court: That includes the one originally shown in typewriting on this sheet PX-171? A. It does, Your Honor.

The Court: And these with the increased percentages? A. That is right. They were all performed within a period of some two weeks or so, the higher concentration ones. They probably started in the latter part of June, perhaps the last week in June, something like that. I haven't the exact date that they were started, but it was during the present summer.

By Mr. Lyon:

Q. Doctor, now have you run any other tests? Are you sure you haven't run any other tests on the subject of

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this inhibitor patent in addition to those you have brought into this case? A. In addition to the data that was presented this morning, is that your question?

Q. Including that. Including all the data that you have brought in either this morning or any other morning, are you sure there are no other tests you have made on the subject? A. We probably have made other tests.

Q. Well, where is the data on them? A. They are not included here because the work on that in my opinion was not complete.

Q. Well, have you ever tested any samples delivered to you by any representative of the plaintiff and said to be samples from the defendant's operations, other than the samples from the particular wells that are mentioned in the reports that you have already presented? A. Yes, I do recall one other sample.

Q. I believe you did mention a well that you tested? A. I mentioned a well and at least two or more samples from that well.

Q. Those are all the samples you ever had submitted to you to test say for inhibitors? A. So far as I recall no samples have been submitted to us other than from the wells already mentioned, including at least another well.

Q. Were any samples ever delivered to you by the defendants purporting to be samples from the defendant's operation taken in Kansas? A. I believe not.

Mr. Lyon: It is not clear on the record, Your Honor. Perhaps we can clear this up. Plaintiff, I believe, has made some statements as to whether or not they procured other samples from the defendant's operations around the country, or delivered other samples, and I am informed that many samples have been furnished to plaintiff, and I may be wrong about it. I don't know it of my own knowledge. I only know what is told me, and I would like to know that. I would like to know if they had it tested by this witness, because there is some issue here or may be some issue as to how far the court would treat particular individual instances as representative, and Your Honor has already seen

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there is considerable variation, even in the materials presented to you now.

Mr. Conner: This suit was filed on June 15, 1939. Before we filed the suit we had procured all the samples that we are now relying on, except such samples as defendant gave us during the taking of depositions. Now, the intimation made by Mr. Lyon, the record is clear. We have obtained samples of a few in Kansas, and a few in Texas, but those samples were all obtained after this suit was filed, merely for our own benefit to substantiate that what they were doing in Michigan was also taking place elsewhere.

Mr. Lyon: Let's have no mistake on it. Because we will call a witness on this.

Mr. Conner: And the later samples were never submitted to Dr. Bartell at all. The only samples he obtained were samples taken in this state in the months of August and September of 1938, and one sample taken in April of 1939, all prior to filing this suit June 15th. Defendant's intimation here is we have taken samples all over the country and picked Michigan where the infringement is. That is not true, Your Honor. The only samples we obtained after the suit was filed were obtained in Texas and Kansas.

Mr. Lyon: Mr. Conner, just so there will be no question of inadvertence in your statement, I want to have it definitely understood, because I plan to call a witness on the subject. Are you stating that numerous samples from the defendant's operations taken in Oklahoma and Kansas in the years 1936 and 1937 were not delivered to and received by the plaintiff?

Mr. Conner: No, I am speaking only of what I know. I wasn't with the plaintiff company until the first day of 1938. What transpired before then, I wasn't responsible for and do not have. I am speaking and saying it was my duty and job to obtain the samples for this lawsuit. I personally did not take them; the boys brought them in to me. Samples may have been obtained prior to 1938. I don't know.

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Mr. Lyon: That is what I am bringing out. Counsel says there were no samples; now he says he doesn't know.

Mr. Owen: There is one other, the Knight well, that I spoke of the other day.

Mr. Conner: I mentioned it.

Mr. Owen: That is going to be referred to in connection with the other patent.

The Court: Well, with that—it is my understanding that all the samples which you ever gave to the doctor, the samples taken prior to the starting of this lawsuit, are then accounted for,—

Mr. Owen: That is all that I know anything about, Your Honor.

The Court: I am satisfied that that is so.

Mr. Owen: No, I will have to apologize to you on that. There was another sample taken—another storage sample—taken when, Mr. Conner?

Mr. Conner: Some time in April, as I recall, of 1939, prior to the filing of the suit.

Mr. Owen: I think that storage sample was delivered to Dr. Bartell, and I think he analyzed it.

Mr. Lyon: Did he make any tests on it?

Mr. Owen: No different from the others.

Mr. Lyon: Did he make any tests on it?

Mr. Owen: You will have to ask him about that.

Mr. Lyon: What I am trying to do is to get all of this work in here, on Your Honor's theory that all of it should be in here.

The Court: I knew that you would, and I was trying to—I know these things are confusing to me, and I think possibly they might be to Dr. Bartell and everybody else, so I was letting counsel try to refresh the doctor's memory about it so that we could get the facts out.

Mr. Owen: My recollection is now as to the reason we did not include those—that later storage sample, was because it was taken just about the time the Knight well was treated, and I think it will be referred to in connection with the Knight well; but if counsel wants to get the information out now, I have no objection to it.

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Mr. Conner: The Knight well was treated April 24, and the storage sample was taken April 26, and we were not relying on the Knight well, so we didn't include the storage sample.

Q. Well, did the plaintiff ever furnish you or did you ever obtain in any way any sample of any of the inhibitors that may be used by the plaintiff? A. I don't recall whether plaintiff has furnished us with any of their inhibitor.

Q. Well, did you obtain it in any other way? A. Oh, yes. We obtained them in other ways. Naturally we would have some of them in stock in our own laboratory, and some I obtained from supply houses, such as Eastman.

Q. Now, you brought in a—just strike that out. You don't have any means of knowing what inhibitors plaintiff has used or is using in its acid? A. I don't believe I have any direct information covering that point.

Q. What do you mean by direct information? Do you have any indirect? A. Not other than hearsay. I may have heard it suggested plaintiff is using arsenic or something of that sort, but specifically, no, I have no specific information.

Q. Do you find anywhere in the Grebe-Sanford patent in suit, No. 1,877,504, any direction or statement as to what amount of the specific inhibitor mentioned in that patent shall be used, other than the amount of arsenic compound? A. I don't remember any such directions, no, other than for the specific example of arsenic.

Q. There is no teaching in the patent or no specification or quantitative figure given as to how much of the other inhibitors mentioned therein may or should be used, isn't that correct? A. I don't believe any mention is made of the amounts of other inhibitors which may be used.

Q. Is there any mention in the patent as to— A. (Interposing) Other than—I will qualify that—in Claim 1 the statement is made that an aqueous hydrochloric acid solution may be used to which has been added "a relatively small amount of an agent capable of inhibiting action of the acid upon metals."

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Q. Now, what is your understanding of what "relatively" refers to. It says "relatively small." It is small relative to what? A. It might mean anything, depending upon the system one was working with. Working with the substances such as we normally work with in surface chemistry a relatively small amount might mean as small as one part per million.

Q. I am not asking you what it might mean. I am asking you what it does mean? A. That is what it does mean to me.

Q. It means how many parts in a million? A. Oh, it might be one or a fractional part.

Q. I am not asking you what it might mean. I am asking you is there any definite meaning to this phrase that you called attention to. If so, give it to us. A. Well, relatively small amounts certainly would hardly be taken to indicate more than ten per cent.

Q. What makes you think so? A. Well, simply my judgment would indicate that relatively small means exactly what it says, relatively small.

Q. Does it include up to ten per cent? A. I wouldn't expect it to, as I mentioned, anything like that, or five per cent.

Q. What is the basic figure to which this word relatively refers? What is the practice which it is distinguishing from, do you know? Is it identified in the patent? A. The patent refers specifically to inhibition and the main designation is that a relatively small amount of material may be added to produce inhibition and the inhibition effects would tend to be the measure of the thing that one is after.

Q. Is that the best answer that you can make to my question? A. Well, the answer to the question is that to me the term "relative" would represent a comparatively great leeway in the selection of compounds and naturally compounds with different properties might require quite different amounts to bring about a given effect.

Q. I am asking you to what should this word "rela-

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tively small amount," or these words "relatively small amount" be distinguished. What is the practice which these words are used to distinguish from? A. Well, the word "relative" as used in this particular patent is written for one reasonably skilled in the art to interpret.

Q. You have to know the prior art in order to be able to interpret it, is that your answer? A. No, not necessarily. I refer to the art of chemistry, surface chemistry.

Q. Now, does commercial hydrochloric acid as determined by your test contain relatively small amounts of copper and lead? A. It contains small amounts of copper and lead.

Q. Relatively small amounts? A. Yes, they are relatively small amounts.

Q. Now, Doctor, let us take mercaptans. They are mentioned as inhibitors in line 3, page 2 of this patent. A. Yes.

Q. Does this patent tell you how much mercaptans to employ in order to constitute adding a relatively small amount of an agent capable of inhibiting, and so forth? A. The patent does not tell what amounts to use.

Q. What? A. The patent does not state specifically the amounts to use, other than a relatively small amount.

Q. Is that the extent of the definiteness of the patent, as to how much of these inhibitors to use, other than the specific formula given in connection with the arsenic compounds, and the 1 to 5 per cent statement at line 86 on page 1? A. The statement is made that other inhibitors may be used, and it specifies the reference to the organic sulphur compounds, such as mercaptans. It does not refer to the definite amount which should be used.

Q. Well, does it tell you how much you are to inhibit the acid, distinguishing now from the quantity of inhibitor to be added, we are now referring to the effect of the inhibitor, and, does it tell you what the magnitude of the effect is to be? A. It refers to an inhibitor which will decrease the danger of damaging the metal portions of the well.

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Q. Does it say how much? A. It does not say how much.

Q. Doesn't it tell you the amount of the inhibitor, how much to inhibit this acid, and doesn't it tell you by the effect wanted as to how much you should inhibit the acid—is that your testimony? A. The last part of that question, yes, it does refer to the effect desired.

Q. Well, does it give you a definite measure of the effect that is to be accomplished? A. Enough so that there will not be damage to the casing, for example; and beyond that, there are no specific directions or specifications that I can recall.

Q. Does it say preclude any damage to the casing, enough to preclude any damage to the casing or pipe? A. Well, in my opinion it refers to making use of the acid practically so that the—well, it is my understanding, and as repeatedly has been indicated, that the non-inhibited acid will have a much greater action on the metal parts of the well equipment; while the use of inhibitors, such as these mentioned, prevents damaging of the casing to the extent certainly of making the operation practical.

Q. Well, what I am getting at, does the patent contain any criterion as to how much the acid shall be inhibited? If so, what is the criterion given in the patent? A. It gives one example of the use of the arsenic compounds and states the amounts of the arsenic compound that can be used.

Q. And in your test with 50 c.c. of acid on the specimen of strap iron without agitation that was 97%? A. That is right. That is per cent inhibition.

Q. Does it give any other criteria or any other measure except that? A. Well, the one to which I have previously referred. An effect which will prevent the danger of damaging the casing.

Q. Doesn't it say how much it protects the casing or pipe in that? Does the patent say? A. Well, there is this statement—"In actual practice this method has never been generally adopted due to the fact that the acid"—and that

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refers to uninhibited acid—"attacks metallic casing, pump and so forth, about as actively as the rock." And so the implication would be, certainly, that these inhibitors will so inhibit that the action on the casing certainly will be far less than that indicated by the statement I have just read.

Q. Have you made any test to determine whether or not uninhibited raw commercial hydrochloric acid will attack well pipe about as fast as it will attack lime formation? You know that isn't true, don't you? A. I have made no test to get a comparison.

Q. You know it isn't so, don't you, as a chemist? A. I wouldn't go that far to make that statement.

Q. You wouldn't? You made ordinary tests of pouring hydrochloric acid on calcium carbonate or lime. Every chemist does that in high school chemistry. A. But more may be implied in this case. The limestone referred to perhaps is the rock material within the earth formation and it may be that the acid cannot readily get at that material so as to react as rapidly as it would if the material were in a beaker right in contact with the acid. But the acid must get to the limestone before it will react.

Q. Have you computed in thousandths of an inch how deep the corrosion of acid took place in the experiments that you have made? So you can just give us an idea of what it is. A. I haven't made such computations.

Q. Those pieces you used were how thick? A. About an eighth of an inch.

Q. And it is true, is it not, that the greatest corrosion in any of your experiments that you got was less than a thousandth of an inch in 16 hours? A. Well, I couldn't give you exact value but it was nothing approaching the eighth inch depth.

Q. Why can't you give me the exact figures? You can compute it right off your papers, can't you? A. Assuming the value were around 4% loss in weight would indicate—

Q. (Interposing) On all sides. A. (Continuing) —would indicate that there had not been in those tests a

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great depth of penetration, unless by chance the penetration should have been in spots or something of that sort.

Q. Well, I am assuming you get an average penetration. You can see offhand it is of the order of less than a thousandth of an inch, isn't it, from the figures you have just referred to. A. Well, I wouldn't say a thousandth of an inch.

Q. Well, you better calculate it then. It won't take you but just a second. You know the size of the test piece and you can assume the maximum four per cent loss, and figure the area of the sample and tell me what the depth of corrosion would be. I can add one thing to help the doctor, remembering that the penetration is from both sides. I think you will find it is two per cent of one-eighth. A. No, it is not as simple as that.

Q. Did you make the calculation, doctor? A. Yes, I did. Using certain assumptions that may or may not—well, that would not be strictly correct, of course, making the assumption that all the loss comes from the side of the plate, which, of course, isn't quite true, but assuming that it did, and assume that the change in thickness was uniform of the plate, the total loss of iron would be expressed in something like five thousandths of an inch.

Q. Now, then, that means on the same assumption two and one-half thousandths on each side, does it not? A. Yes, calculated on that assumption the loss from each side would be in the neighborhood of as you say two and one-half thousandths.

The Court: And inasmuch as there would also be a layer around the edges it would really be a little less than the figures you have given? A. Slightly less, provided the action were uniform throughout, all over the surface.

The Court: And if you applied the loss it would come at the ends and side of the narrow strip running around it, to the two wide sides, as I understand it? A. Yes.

Mr. Lyon: Well, now, you do not find in this Grebe and Sanford patent in suit any definition of the extent to which the acid is to be inhibited, either measured in the

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amount of inhibitor used or measured in effect to be accomplished, other than what you have already stated? A. I believe that is right.

Q. Why haven't you mentioned the phrases used in line 15, page 2, where it says, "And such strength of acid, the corrosive action thereof upon metals, particularly iron or steel, can be largely or substantially inhibited"? A. Well, that is a further indication of the results.

Q. Is that a definite indication? A. Which would be expected.

Q. Is that a definite indication, anything definite about it? A. The word "can" appears, "with such strength of acid, the corrosive action there upon metals, particularly iron or steel, can be largely or substantially inhibited by adding thereto a relatively small amount of an arsenic compound or other inhibiting agent."

Q. Well, now, what does "largely" or "substantially" accomplish here? Does it give us any definite quantitative measure or effect that is to be accomplished? A. Well, I would feel that the implication is to the fact—is to the statement that I made in my earlier answers, that corrosive action can be largely or substantially inhibited, to the extent that the process is made practical the casing is protected.

Q. I want to add to that the sentence commencing at line 25 on page 2, which reads,

(Reading): "Due to the presence of the inhibitor there will be no substantial attack upon the pump tube, or upon the well casing."

Isn't it true that there is no quantitative indication or extent of the inhibition called for by this patent except that it shall be such that there will be no substantial attack, or, to put it the other way, that the acid is largely or substantially inhibited? A. Yes, to a degree, but it is assumed that the uninhibited acid will give what would be referred to as a substantial attack, so the implication is that one must compare the attack with the non-inhibited acid with that of the inhibited acid.

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Q. Now, let us assume that we have chemically pure acid, which has the maximum amount of corrosive effect; and, let us assume that we have a completely inhibited acid, now, does this patent tell you at what point intermediate to those two you will be—on one side—accomplishing what is called for by that patent, and on the other side not reaching that accomplishment? A. Not in terms of quantitative figures.

Q. Well, the only terms that exist for consideration are these terms “largely and substantially inhibited,” and the term “no substantial attack,” so far as the effect of any measurement in this patent is concerned, isn’t that true? A. Yes. That is essentially true.

Q. I think I will add to that, to make it complete, the phrase appearing at line 96 on page 2, “without appreciable damage.” A. Yes. That term also appears.

Q. Well, now, taking all together these terms, which I understand are, first, the phrase at line 15 on page 2 reading “can be largely or substantially inhibited,” and next the phrase at line 26 on page 2 reading “no substantial attack,” and the next and finally the phrase at line 96 on page 2 reading “without appreciable damage,” will you tell me at what per cent of corrosion or inhibition, either one, lying between chemically pure acid and one hundred per cent inhibited acid marks the distinction between practicing this patent and not practicing the patent? A. I can’t tell you that.

Q. Why not? A. I do not know.

Q. Can’t you tell from the patent? A. But I have been asked for a specific value and my experience is not such that I could give you a specific value.

Q. You cannot find that value in this patent; is that correct? A. No, the value is not given in the patent.

Q. You are not willing to subscribe to the proposition that the phrases “largely or substantially inhibited” and the other phrases connote an acid which has been inhibited to the extent advertised by the plaintiff, to-wit, 99 per cent, or the extent you found with the arsenic formula, to-wit, 97

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per cent or thereabouts? A. The question is put in the negative there somehow. I would like to answer it by stating that I am willing to subscribe—if you will read the question once more, I will try and answer it.

(The question was repeated by the reporter and the question in writing was handed to the witness.)

A. (After examining the question): I would be willing to subscribe to the phrase "largely or substantially inhibited," when used to refer to the plaintiff's acid which has been inhibited to the extent of 97 or 99 per cent.

Q. Would you be willing to do so as applied to the Detroit Chemical Works acid which when tested with the Atha Supply Company metal gave a per cent of reduction in corrosion of 18.4 per cent? A. I would be willing to state that that acid has been inhibited.

Q. Would you be willing to say it was largely or substantially inhibited? A. It would depend upon whether—I would feel that it would depend somewhat on the purposes to which the acid was to be put.

Q. Well, assume that we are going to use it for acidizing a well in a limestone formation? A. I would say the acid is inhibited, and I would feel that the tests, such as I have described, showing inhibition, might not serve as a sufficient criterion to indicate the extent to which the inhibition would exist in the well.

Q. Now, in order to obtain any meaning for the word "substantial," or "largely," or "appreciably," which are comparative words, as I understand it, it is necessary to know the starting point with which to compare them. Do you agree to that, doctor? A. In general, yes.

Q. Now, what do you understand to be the starting point in the case of the words that we are inquiring about, chemically pure acid or commercial raw acid? A. Well, the only definite yardstick, of course, would be the chemically pure acid.

Q. You do not believe that this patent, in discussing inhibited acid, is intending to go back and use chemically pure acid as a starting point, to the exclusion of commercial

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raw acid, do you? A. That would not be my opinion, no.

Q. If we are going to use chemically raw acid as the starting point for this comparison, can you place any limit on the percentage of reduction in corrosion that you would tolerate in such a commercial raw acid? A. I feel that it would be necessary to place some restriction on that, yes.

Q. Does the patent give you any guiding restriction, the patent in suit, the Grebe-Sanford patent? A. Not in terms of quantitative values, no.

Q. How are you going to tell from this patent, if you can tell, what the starting point is that you are to employ for the purposes of comparison in interpreting these terms "largely," "substantially" and "appreciably"? A. I have nothing to add to the statements that I have previously made on the same question.

Q. Well, you mean to say, then, that there is no criterion to that starting point in the patent? A. There is no quantitative scale set up, no.

Q. Now, what we are interested in in the— A. (Interposing) In terms of figures.

Q. What we are interested in when we talk about substantial attack on the pipe or the words "largely" or "substantially" inhibited, is the corrosive effect of the acid in question, are we not? The rate at which it would corrode pipe or steel? A. That is involved. That is involved; yes.

Q. Now, would you say that this patent contained any criterion by which you could state, with respect to the corrosion rate, what was embraced within the terms "largely" or "substantially" or "appreciably" as distinguished from what was excluded by those terms? A. There are many types of experiments or processes in which it would not be possible to set up, perhaps, a simple set of criteria to cover all cases. I have already called attention to the fact that when the system is allowed to remain unagitated one gets a certain type of—certain rate of corrosion, while if the system is agitated somewhat one obtains a different rate of corrosion. If one has a certain ratio of metal to acid one gets a certain rate of corrosion; if the ratio is somewhat

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different one obtains a different rate of corrosion. So it is perfectly evident from that statement alone that it would be a little bit difficult to set up a quantitative measure covering this word "substantial inhibition," for these different inhibitors.

Q. Well, now let's compare again the matter that I brought up here the other day. On the basis that the defendant's sample which you tested in a particular manner showed 47 per cent reduction in corrosiveness and the plaintiff's formula of this patent showed 97 per cent under similar conditions, I believe you testified that the defendant's acid was seventeen times as corrosive as the plaintiff's formula. I use the word "plaintiff's formula" to refer to this specific formula in the patent. Now, is there anything in the patent in suit to indicate whether or not one acid is largely or substantially inhibited with respect to the other when that acid is 17 times as corrosive as the other?

A. No, there is nothing in the patent referring to that. Neither is there anything in the patent demanding that certain volume relations be observed.

Q. Now, if the plaintiff's—I mean if the specimen of the defendant's acid is 47 per cent reduced in corrosiveness, and you compare it with this Detroit raw commercial acid which is 18 per cent, how many times more corrosive is the Detroit raw commercial acid than the defendant's acid? A. Well, if the reduction in corrosiveness of the one is 47 per cent it means its corrosive effect still is 53 per cent. And if the reduction in corrosiveness of the other is 18 per cent it means that the corrosiveness of it is 82 per cent, so the ratio is 53 to 82.

Q. Which means that the raw commercial acid in question would be one and one-half times as corrosive as the defendant's acid, does it not? A. Approximately that. Not quite.

Q. Well, now, let's apply that to these terms "largely" "substantially" and "appreciably" in this patent. Would you say that the defendant's acid in that case was substantially as corrosive as the raw commercial

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acid that I have referred to since it is only one one-half times as corrosive, or would you say it was substantially as corrosive as the formula of this patent in suit since it was 17 times as corrosive? A. To give a complete answer to the question I would want to test the corrosiveness under various conditions.

Q. I am just taking—accepting for the moment that you are going to answer based on these comparative tests—that you testified to, to-wit: That the Detroit raw commercial acid had an 18% reduction in corrosion whereas the defendant's sample had a 47% reduction in corrosion under the same conditions. A. I would say it was substantially more inhibited, yes.

Q. Well, is it substantially like the raw commercial acid with respect to its rate of corrosion or is it substantially like the formula of this patent in suit with reference to its rate of corrosion? A. It might apply to both. The term "substantially" might apply to both.

Q. Might apply to both? Will you please explain what you mean by that? A. May I have the original question read, please?

(Whereupon the question was read by the reporter.)

A. It is rather a difficult sentence to analyze. May I have it once more, please?

(Whereupon the question was again read by the reporter.)

A. I have answered, I believe, that I feel "substantially" would apply in both cases. Can the question be made more specific if that answer is not satisfactory?

Q. Is that the best answer you can give to the question? A. I feel it is a suitable answer.

Q. Well, let's put it this way: Compare it to the raw commercial acid on the one hand and the 97% inhibited acid of the patent in suit on the other hand. As to which is the rate of corrosion of the defendant's sample most comparable? Which is it most substantially like? Is it substantially more like the raw commercial acid or substantially more like the formula of the patent in its corrosion rate?

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A. If I understand the question correctly, the truck tank sample with its reduction in corrosiveness of 47%—

Q. (Mr. Lyon interposing): Remember it is only one one-half times as corrosive as the raw commercial acid. Now, isn't it more like that in its corrosion rather than it is like the corrosion rate of something that it is 17 times as corrosive as? A. As to the amount of corrosion which would be caused by these two acids under consideration under which the experiments we are referring to were run, it is true that for a given experiment the truck tank sample would reduce a loss in weight of iron more nearly in amount like the raw commercial acid than of the sample of the defendant's inhibited acid.

Q. Now, as you understand the wording of this patent as a man skilled in the art, would you say the patent includes and covers the use of that 18 per cent Detroit raw commercial acid? A. I would feel it might if it were found that under conditions of operation that Detroit commercial acid produced an effect which made it possible to use it to advantage. May I have the question before I put the period there, if you please, to be sure that I have understood the question?

(Question read.)

Q. I mean by 18 per cent the raw acid has an 18 per cent reduction in corrosiveness as compared with chemically pure acid? A. And my answer is it might.

Q. That it might? A. It might, yes.

Q. I can't get very far with the word "might." A. No.

Q. In your opinion does it or does it not? A. I have just previously stated that under the condition of my experiments it was shown that the acid is inhibited. Now, whether or not that inhibition might be sufficient in practice to make that acid outstandingly better—

Q. What is that term you used? A. Outstanding or substantially or very materially better. As to whether it would be materially better under other sets of conditions would have to be determined by running experiments under

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other conditions. My experiments went this far, they showed that acid was inhibited, contained something that served as an inhibitor, and that is as far as that particular set of tests of mine that I described were supposed to go.

Q. Well, now, you have referred to the fact that you would have to determine whether or not that amount of inhibition had a quantitative effect, that is right, isn't it? A. Right.

Q. Now, does this patent tell what this quantitative effect is? A. It doesn't mention it in terms of figures, no.

Q. Does it mention it in any definite terms? A. It implies that the effect must be such as to make the improvement of value.

Q. Of value. Is that all that it claims now; is that all the quantitative indications of this patent on that point signify to you? A. To me the patent signifies exactly what it says in claim 1. "In a method of increasing the output of a well for producing a fluid mineral product such as oil, gas, water or brine, the step which consists in introducing into the well an aqueous hydrochloric acid solution to which has been added a relatively small amount of an agent capable of inhibiting action of the acid upon metals."

Q. Now, why wouldn't that fit any commercial hydrochloric acid which was put down a well for the purpose stated for that commercial hydrochloric acid containing amounts of copper and lead? A. Apparently the patent refers to the use of commercial acid; and apparently the patent refers to the addition to such commercial acid of agents which will produce an inhibiting action.

Q. Do you find that definitely stated in the patent? Do you find that this addition is to be to commercial acid, as distinguished from chemically pure acid? If so, will you please point that distinction out in the patent, or, that statement? A. I do not recall that the word "commercial" is used in respect to use in the patent.

Q. Do you understand from reading this patent that when they speak of an addition of a small amount of an agent capable of inhibiting the acid, that they are speaking

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of an addition to commercial acid, or are speaking of any addition to chemically pure acid? A. Well, it would be my interpretation that the patent refers to the addition of such agents to commercial acid.

Q. And, therefore, any inhibiting agents that were present in commercial acid and raw acid as a result of its manufacture would lie outside of the added agents to which the patent refers? A. I would think so, if the manufacture is by a normal process of manufacture.

Q. It is true, is it not, that all raw commercial hydrochloric acid contains some amounts of lead and some amounts of copper? A. I could not say how much.

Q. Don't you believe that to be true? A. Well, all I have examined here have contained some, yes, sir.

Q. Now, then, I want to find out if I can if this patent gives us a starting point with which to compare either the amount of agents that are to be added, by weight, or by effect, and I think you have stated now the first premise in establishing that starting point is that we are to start with raw commercial acid though we are not restricted, or not set back to chemically pure acid. Do you agree on that? A. I would be inclined to, with the proviso that I made in my last answer.

Q. Now, then, how much lead or copper would you allow to exist within that raw commercial acid, and still be within the starting point to which we are referring? A. (after examining a book): To answer that question correctly, I would want to—if a definite criteria is to be set up to cover all time, I would want to know the average composition of practically all commercial acids. The evidence is that the available commercial acids contain a copper content somewhere in the neighborhood of three-tenths of a part per million, when those acids are diluted down to approximately 15 per cent acid.

Q. Now, you say in the "neighborhood." I suppose that is the average figure you have given? A. It would be close to the average, the values I have.

Q. What are the extremes? A. The extremes are as

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follows: From .24 up to .37 of copper, parts per million.

Q. Now, do you know whether or not that represents the extremes that would be found in actual commercial acids? A. They happen to be the values in all that I have happened to analyze this way.

Q. You haven't made any study further than that? A. I have not made a study further than that.

Q. Do the handbooks, if you know, contain any data on the percentage of copper and lead which may be expected in commercial hydrochloric acid? A. I don't know of such data.

Q. Have you ever examined them to see? A. No, I haven't. I don't believe you would find it. I don't believe you would find it.

Q. Does the patent in suit give any quantitative figure or quantitative value for the amount of inhibitor or copper or lead that may be allowed within the commercial hydrochloric acid which you say is to represent the starting point for the purpose of comparison in this patent? A. No, it does not.

Q. Then if you were the operator of a well, and you employed a service company to come out and acidize your well. They came out and brought a tankful of acid, and before that acid went down the well you tested the acid to see whether or not it was inhibited in the sense of this patent. What would guide you at that point in saying, "I can use this acid without violating the patent," or, "I must tell this operator he cannot be permitted to put that acid down my well because it will infringe the patent"? What would you have to know and how would you determine it, assuming you had the patent before you and were thoroughly familiar with the wording of the patent? A. May I have that question, please?

(Question read by the reporter.)

A. May I ask a question about the question?

Q. Oh, yes. A. The question was if I were the operator?

Q. Yes? A. Then naturally, if I were the operator, I

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would know what I now know, and if I were to examine that acid and found that acid to contain copper, for example, in amounts somewhat greater than the values I have stated, I would have my suspicion that copper had in some way gotten into that acid after having left the manufacturer. Hence, I would be suspicious that that acid might be inhibited.

Q. Well, let's suppose you are just the ordinary oil well operator to whom this patent is directed, and you haven't made the tests that you have? How could you tell then? A. Probably if I were an oil well operator I would take the commercial acid delivered to me.

Q. Well— A. If I were the operator.

Q. I am saying that you have heard that the Dow Company is asserting this patent, and you are liable to be sued if you put any acid down the well that is covered by this patent, and this company that you have employed brings out some acid, and you say, "Wait a minute. I have got this patent here and I have read it. I want to test that acid and see whether it is an infringement of this patent or not." How could you tell? A. I would say you better take that acid to the laboratory and have the chemist investigate that acid and determine whether or not that is inhibited. That would seem the logical thing to do.

Q. Now, you have done that. Would you say that the acid—if you, we will say, found the acid had an 18 per cent reduction in corrosive effect, that that established that the acid was covered by the patent? A. I would be rather suspicious of the acid.

Q. I am not asking about being suspicious. I am asking you would you be able—would that establish, as you read this patent, one skilled in the art, is an infringement of this patent? A. I would feel that it might be.

Q. I am asking just a plain, simple question, and not whether it might be. But as you read the patent, does it or does it not? A. If it would be discovered that an inhibiting agent was deliberately placed in that acid, as it may be, why then I would feel I was infringing.

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Q. If it hadn't been deliberately put in there but had just arrived there in the normal manufacture of the acid, would your answer be the opposite? A. I have indicated that by a previous answer. Yes, in normal methods of manufacture without the addition of anything.

Q. How much of the inhibiting agents arriving in the acid only due to its normal method and process of manufacture would you tolerate? Or, if you want to express it in per cents of reduction in corrosion in a raw acid, without saying that it violated this patent, assuming that there was no addition subsequent to the normal manufacture of the acid? A. Well, I would feel that an amount such as was represented by the storage tank acids of the defendants would quite likely indicate a suitable value.

Q. That isn't my question. I am asking you how much greater than that could it be and still be permissible? A. Well, anything greater than that might indicate the presence of an added inhibitor.

Q. I am not asking you what it might indicate. I am asking you, assume that it isn't added in the sense that you are referring to, would you allow any amount of inhibitor in there that was caused by the normal method of manufacture of the acid? A. If it isn't added, it can't get there. My answer would be inclined to be I see no reason why it should.

Q. What do you mean "if it isn't added it can't get there"? A. If more of these metals are present in the truck samples than in the storage tank samples, the metals must have gotten there in some way.

Q. Well, would you allow the use of a raw commercial hydrochloric acid for the purpose of the starting point, which we are interested in, if that acid contained no added inhibiting agent in the sense that you referred to but contained amounts of copper and lead sufficient to reduce the corrosive effect of the acid by 18%? A. I would be very suspicious of an acid that would reduce the corrosiveness to 18%.

Q. I am not asking you would you be suspicious of it.

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I am asking you if you would allow it. A. If I were in the position that you have suggested I consider myself and had the responsibility attendant to that position, I would want to check up on it immediately. So in that respect I would not allow it.

Q. Then, as a matter of fact, in order to establish a starting point which is necessary for interpreting this patent here in suit, you cannot do it from the patent itself. You have to go and find the acid and examine its method of manufacture, make tests on it to determine the amounts of copper and iron it contains, and find out its per cents of reduction in corrosiveness rather than reading that and relying on the data that is in the patent in suit, is that correct? A. The patent does not discuss the normal impurities.

Q. Then, as a matter of fact, you couldn't establish the starting point from this patent from the wording of the patent itself? You have to go outside of the wording of this patent and make some other kind of determinations?

A. I wouldn't say that because I have indicated that I would feel that it would be perfectly permissible to use commercial acid, assuming no inhibition, but if I found the acid did contain inhibitor, then I would feel that it was time to investigate.

Q. Well, all right. Now, can you get the answer as to those acids from this patent? A. No.

Q. Or have you got to go out and look at something else? A. No, you can't get the answers from that patent. It doesn't tell about the manufacture of hydrochloric acid.

Q. And the point that you have got to ascertain then is whether or not the manufacturer deliberately added an agent that wouldn't get into his acid by its normal method of manufacture, is that the point? A. I think that is the thing one should know, yes.

Q. Now, how are you going to tell whether this copper and lead got into the acid in the normal method of manufacture, or got in there by intention? Do you know enough about the manufacture of commercial hydrochloric acid so

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you could go in a plant and tell whether they were deliberately adding copper and lead, or whether the presence of copper and lead was due to the normal operation of the manufacture of the acid? A. I could tell this; I could tell whether or not the copper and lead content was above that of the acid when manufactured, and to answer—

Q. (interposing): We are not talking about that. We are talking about this examination to see whether it has been added or not. What do you mean by added, something that you strictly—the term “added” is something after the acid is finished, or something that was done in the manufacture of the acid? A. I refer to after the acid is finished. Perhaps I didn’t answer completely your first question there.

Q. Then you think that the real criterion for this patent and the starting point, so-called, is that this patent covers the deliberate addition of an inhibiting agent to a commercial raw hydrochloric acid where that acid is to be put down an oil well to treat a lime formation, you think that is what the patent covers, irrespective of the amount of acid. I mean irrespective of the amount of inhibitor added, and irrespective of the effect as to the percentage of reduction in corrosion? A. I feel that the patent does call for the addition of material to normally made hydrochloric acid which will lower—which will give an inhibiting effect.

Q. Irrespective of the amount of the added agent, or irrespective to the extent of the lowering of the corrosiveness? A. That is my opinion.

Q. That is your opinion? A. Yes.

Q. Do you find that stated in this patent? A. As to the amounts of material?

Q. Yes. A. Yes, it is.

Q. Isn’t the information— A. (Interrupting): It is stated in these words: “The hydrochloric acid solution to which has been added a relatively small amount of an agent capable of inhibiting action of the acid upon metals.” That is the statement.

Q. That is to be read, is it not, in the light of the speci-

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fication, which refers to largely or substantially inhibited, at line 15, so that there will be no substantial attack, as stated at line 25? A. The claim 1 contains no such word as "substantial." The claim 1 states as I have just indicated, reading the entire claim again, if I may, to have that clear:

"In a method of increasing the output of a well for producing a mineral product such as oil, gas, water or brine, the step which consists in introducing into the well an aqueous hydrochloric acid solution to which has been added a relatively small amount of an agent capable of inhibiting action of the acid upon metals."

Q. All right. Now, how does that claim differ from a raw commercial acid containing small amounts of copper and lead? A. In this way: It says an acid solution, an aqueous hydrochloric acid solution to which has been added a relatively small amount of an agent capable of inhibiting the action.

Q. Well, then, for the difference you depend upon the word "added"? A. Added after manufacture, yes.

Q. Added after manufacture? A. After the normal process of manufacture, that is my understanding of that patent and claim.

Q. And any addition of that kind, no matter how small it is, you think is included and covered by this patent? A. It is covered by claim 1, in my opinion.

Q. But you think the addition must be intentional? A. Well, I would feel that is a matter of law.

Q. I am just asking you to read this patent now. As I understand it you are saying that the difference between this claim, and this patent as represented by this claim, and the starting point just outside of the patent resides entirely in the intentional addition of the inhibitor after it is manufactured? A. I do not think that is a fair statement.

Q. Do you know anything about the defendant's method of operation? A. No, nothing, only—

Q. Have you made any tests on it? A. I know only what I have heard about the method. I have never seen the method carried out.

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Q. Have you ever made any tests having any bearing on the defendant's method? A. Why, it—

Q. Other than these that you have produced here? A. I think practically none.

Q. Well, any? A. Well, in considering any preliminary experiments, I think—at the moment I think of practically none. What they might be, they would be in the nature of preliminary experiments, or something of that kind, if we made any; but those are essentially all of the experiments that we have made. The information that we have here was essentially the information we set out to get from our experiments, and which we have presented.

Q. Do you know whether or not the purpose of the lead plate bonded into the defendant's tank is to protect its tanks? A. I think I have heard the statement that they were there for that purpose.

Q. Have you any idea how much longer the defendant's tanks last with the lead plate bonded in there than they do without it? A. I have not.

Q. Can you give us an idea, based on your knowledge of the corrosiveness of the raw hydrochloric acid? A. I couldn't give data that would have much bearing on that point, for the simple reason that I am inclined to believe that information one can obtain concerning normal action, as far as metals are concerned in solutions at the source, will be quite different in solutions of 15 per cent acid, and I have not enough information to hazard a guess as to what the reactions would be in the 15 per cent hydrochloric acid.

Q. You are not in position then to compare the causes for the existence of these small amounts of lead and copper in the well, as it arrives at the well, with respect to whether or not that is incident to the protection of the defendant's tanks? A. I have made no study of that.

Q. Further, in connection with this starting point for patent 1,877,504, what is the difference in corrosiveness of the two ordinary raw commercial hydrochloric acids, and one of ten per cent strength, and one of fifteen per cent strength, or twenty per cent strength? A. I have no data to show on that.

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Q. Well, this patent in suit specifies, does it not, that a hydrochloric acid may be used of the strength varying from 5 to 20 per cent? A. It does.

Q. Or more. And, as a matter of fact, would the corrosiveness or, the rate of corrosion of those two strengths of acid, 10 and 20 per cent, vary more than the difference in variation between the defendant's well acid samples that you tested and the raw hydrochloric acid in the defendant's storage tanks? A. I couldn't say. They might.

Q. Well, try to figure it out, will you? A. You can't figure it out offhand.

Q. What. A. You can't figure it out offhand.

Q. Don't you know anything about the difference in the corrosion rate of 20 as compared with 5 and 10 per cent hydrochloric acids? A. No, nor anyone else, without having access to data of some sort with such experiments.

Q. Now, have you made any—just strike that for a moment. In the exhibit that you produced this morning, Plaintiff's Exhibit 171, you report certain tests with acridine, aniline, pyrodine and quinoline. You also reported your tests with arsenic. Didn't you make any tests of the other inhibitors referred to in the Grebe and Sanford patent in suit, commencing at line 87 on page 1? A. Not that we have completed.

Q. Not that you have what? A. Completed.

Q. Have you ever tested the cyanides? A. No, we have not.

Q. Have you ever tested the organic nitrogen bases? A. Well, some of these things we have mentioned are organic nitrogen bases.

Q. How about the phenyl-hydrazine? Have you tested that? A. That is the one that we now have under test.

Q. How about mercaptans? Have you tested those? A. We have tested no mercaptans.

Q. Why not? A. We just haven't.

Q. Don't you know, as a matter of fact, or haven't you been told that that is the inhibiting agent that the

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plaintiff uses commercially and has used for some years?

A. We have not.

Q. You never asked what inhibitor the plaintiff uses?

A. I don't believe I ever did.

Q. Nobody told you that that is what the plaintiff used or asked you to test that? A. No.

Q. To make any comparative tests of that? A. No one has.

Q. Well, who have you contacted in this case? Who gave you your instructions on behalf of the Dow Company, of the work you were to do in this case? A. I think the legal counsel here.

Q. Which one? Any particular one of them? Somebody come and arranged with you to do this work and told you what they wanted you to do? A. They did. And I stated in the first of my testimony the other day we were asked to do two things, and as to whom it was, I think perhaps it was Mr. Conner. I wouldn't be positive, but I think it was Mr. Conner.

Q. Were the arrangements made with you? A. Yes, they were made with me. I was simply asked to make the—

Q. He looks more like the man that made the arrangement with you than anybody else around here, doesn't he? A. I beg your pardon?

Q. He looks more like the man that made the arrangement with you than anybody else around here, doesn't he?

A. Well, as I recall, Mr. Conner was present the afternoon I was asked to make those measurements. I don't recall who might have been there. I think others were along. Well, I wouldn't be sure. I think possibly Mr. Chamberlain may or may not have been there. I think he was.

Q. I think that is probably safe, he may or he may not. I think that is pretty safe to say that. We are trying to find out what the possibilities were. We are trying to find out what happened. A. What happened, I was asked to make a test of some solutions. I was given those solutions and asked to make the test that I have already mentioned, sample tests.

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Q. That is all you were asked to do? A. That is all I was asked to do.

Q. Did they give you a copy of this Grebe and Sanford patent? A. I don't remember that they did at the time. I have since gotten a copy.

Q. How long have you had a copy? A. Oh, over a couple years.

Q. How did you find out that these tests were pertinent to this patent? A. Well, I suppose from the patent.

Q. How did you know that there was such a patent? A. Well, I suppose the patent was given me, certainly.

Q. Do you remember? When you undertake employment in a case like this to do experimental work and are asked to be an expert witness, don't you know who comes to see you and arranges the matter with you; don't you know what instructions are given you, and what material is handed to you? A. I was not asked to be an expert witness when I was first given the solutions and asked to examine them.

Q. When did you find out you were going to be an expert witness in this case? A. I don't remember. Some time after that.

Q. Have you ever been an expert witness in any other case for the Dow Company? A. I think I have in one.

Q. Have you or haven't you? A. I have.

Q. A patent case? A. It was.

Q. Well, that is the only other one? A. I believe that is right.

Q. Then this isn't so common a thing the Dow Company coming and asking you to testify as an expert for them it didn't make some impression on your mind as to what they wanted and what they wanted it for? A. Just to clarify the issue, I may state the company have asked me to examine things in a referee capacity, which had, so far as I know, no bearing, it did not involve me as an expert witness in the case.

Q. Don't you think it would have been rather an intelligent thing to have done in making these comparisons,

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in preparing for testifying in this case, to have asked the plaintiff which one of these inhibitors they were using and make a test of that? A. I don't see that that has any bearing on the point. That has nothing to do with the things I testified about.

Q. How about slug acid? Did you make any tests with that? A. What do you mean by "slug acid" please?

Q. From oil refining. A. No, we made no tests with that.

Q. How about residues from acid sulphite paper manufacture? A. We made no tests of that.

Q. How did you come to pick these particular inhibitors that are mentioned on your Exhibit 171 out of this list and test those and not the others? A. Well, we had those available and those were definite.

Q. What do you mean you had them available? A. In our laboratory, in our chemical laboratory.

Q. You didn't have any mercaptans in your laboratory? A. I am not sure whether we did or not, and what's more, the particular mercaptan isn't indicated. It might have been any one of a number of different things.

Q. What difference does that make? Make any tests on that? A. We could have tried them.

Q. What? A. One could try any one of a number.

Q. I mean do you know whether it makes any difference—the difference between one mercaptan and another? A. I expect it would.

Q. Have you tried it? A. I have not.

Q. Well, now, you have sand blasted all these samples— A. (Witness interposing) We did.

Q. In the case of each test that you reported here the metal was sand blasted, is that right? A. Before testing, yes.

Q. Isn't it true that sand blasting a surface like that greatly increases the area of the surface that is exposed to the liquid? A. It probably would increase it somewhat.

Q. Well, you know it would, don't you? A. It depends on the condition of the surface before it is sand blasted.

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Q. Did you make any tests so you can tell us how much the area of those surfaces that were exposed to the acid was increased by the sand blasting? A. No, we made no such tests.

Q. Did you try any tests where the samples were oiled before they were put in the acid? A. I don't believe we did. I don't remember such a test. I don't know why I'd do it.

Q. You didn't try? A. So far as I remember, we didn't try.

Q. True, isn't it, in order to corrode a steel surface the acid must wet the surface? A. It must get to the surface.

Q. It must wet it, must it not? A. Depends on what you mean by "wet."

Q. Take your definition of wetting. I am sure it is better than mine would be. A. If you take my definition of wetting, yes.

Q. Maybe you better state to the judge, if he doesn't understand already, what your definition of wetting a surface is. A. Wetting of a surface constitutes a process in which when a liquid comes in contact with a surface there is a change in energy at the interface.

Q. Now, then, if you applied an oil bath or oil film on this metal piece before you dipped it in the acid, do you know whether or not that would have any effect on the wetting of the metal by the acid? A. It's a guess. I would guess it would.

Q. Well, I think it would be a pretty safe assumption, without asking you to give any quantitative values, to assume that the rate of corrosion of a steel pipe by acid flowed down through the pipe would be different in the case of the acid being preceded by a flow of oil than if the inside of the pipe was clean or sand blasted? A. How different I wouldn't know.

Q. But it would be different. A. I would expect it would be some different. How different, I wouldn't know.

Q. And you didn't make any tests along that line?

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Mr. Conner didn't suggest you make any tests with these pieces of metal after they had been oiled? A. No such tests were suggested.

Q. Did he tell you that in the defendant's acidizing process that the acid is preceded down the pipe by a column of oil? A. Well, at the time we started our tests, I don't think he did because our instruction was specific and did not include a discussion of the defendant's process.

Q. Has he since mentioned the fact to you and asked you to conduct any experiments on the basis of oil specimens? A. No.

Q. But has he mentioned to you that that is one factor that will influence the rate of corrosion down a well pipe?

A. The answer to the question would be no, he has not told me that. On the other hand, I may have been told that the oil is in contact with—has been in contact with the pipe, but no one has told me the thing indicated by the question.

Q. Dr. Bartell, referring to the instructions that you received from the plaintiff's representatives as to the work or tests they wanted you to make for the purposes of this case, did they ask you to analyze these samples for lead, copper and iron, or was that your own idea? A. As I recall, that was our own idea.

Q. They didn't tell you that those were examinations or tests that they wanted made? A. As I recall not.

Q. What led you to analyze the samples only for lead, copper and iron? A. Well, an examination of the samples would readily show the presence of considerable lead, so it is perfectly obvious as to why we would test for lead.

Q. You could tell by just looking at the sample? A. No, but the simplest of qualitative analysis would show upon that.

Q. What about copper? A. Copper is not so readily detected. After going that far and finding that lead was present, and knowing that something else was probably present, because of the inhibition effects that we were getting, we naturally tested for other metals.

Q. As I understand it, this inhibition or reduction in

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corrosion that you referred to could not be accomplished by the lead itself, because lead has a very limited action, and the results are due to the presence of copper in conjunction with the lead? A. As I recall, we made a test with lead salts alone to see whether that much lead would cause the inhibition that we obtained, and it did not cause as much as we obtained, so we suspected that something else must be there.

Q. Did you examine the storage samples to see if they contained any other agents or chemicals other than hydrochloric acid, water, and lead, iron and copper? A. We made qualitative tests for other things.

Q. You found some other things, did you not? A. Not in appreciable amounts, no.

Q. Well, didn't you find some arsenic in the storage,—in the raw acid? A. Not with the tests we made, the regular qualitative tests.

Q. You didn't examine sufficiently to determine whether there were any other chemicals in the raw commercial acid which could function as inhibitors? A. We didn't make an exhaustive analysis, no.

Q. I did not ask you about exhaustive. Did you make any analysis? A. I just mentioned that we did make some qualitative analyses.

Q. Have you got a complete analysis of those samples from the defendant's storage tanks, as far as you made a qualitative analysis, have you got a complete report? A. No, I have not, beyond the three metals.

Q. What else did you find in the raw acid qualitatively? A. I don't remember that we found anything.

Q. Would your notes show it? A. Well, after having found lead and copper and after having found the inhibiting effects we did I am not sure we looked beyond that, except we did make some qualitative tests for arsenic.

Q. Was that the only thing you made the test for? A. Just about, I think.

Q. These abouts and maybes are difficult for me to use your testimony on. I asked you, did you make any

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qualitative tests for anything else? A. I will have to consult with Mr. Cardwell.

Q. That is perfectly all right. He is in on this at all stages.

The Court: I suggest one of you help the other in any way you want.

A. Mr. Cardwell informs me we did what I thought we did, we took the regular qualitative analyses scheme for detecting the inorganic constituents and did not find appreciable quantities of anything else.

Q. Well, have you got your qualitative report here so that we can see what you did find in the raw acid? A. I am quite certain we haven't. I don't know we even kept a record of it. Perhaps Mr. Cardwell would be willing to answer that question.

Mr. Cardwell: We have a record of it, but it is not here in the courtroom today.

Q. Is it in town, do you know?

Mr. Cardwell: Yes, sir.

Mr. Lyon: I would like to have it sent down to me, if you would.

Q. Did you examine these—well, as I understand it, you did not make any quantitative tests? A. We did not.

Q. About anything, for anything except lead, copper and iron? A. That is right.

Q. And you say you did not find in the raw acid or in the defendant's well acid at the tank, at the well, any other inhibitor except copper, lead and iron? A. We did not find them, no.

Q. Did you analyze the samples for oil, particularly the tank samples at the well, to see if they contained oil?

A. Well, if there were oil present on the sample one would expect the oil to be on top of the sample, and no analysis was made of the solutions received for oil content.

Q. I believe you stated that in the case of the Crawford sample the oil was readily observable on top of the sample? A. Yes, there was considerable oil on top of the Crawford sample.

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Mr. Owen: I beg pardon. That is the Stella Wilcox.

A. That is right.

Q. (By Mr. Lyon) Excuse me. A. I am sorry.

Q. Now, what other samples from the defendant's tanks at the well did you look to see if there was any oil observable on the surface of the sample? A. We observed to note whether there was oil on the sample.

Q. Was there some in each case? A. There may have been traces on some of them.

Q. Did you examine—did you make a qualitative determination to test for the presence of oil in connection with those samples? A. I don't believe we did, with those samples, because, as I recall, they at most would be but traces of oil on the samples.

Q. Did Mr. Conner explain to you that in these operations from which these samples were obtained from the defendant's tanks at the direction of the Dow Company that the oil was circulated in the system so that the acid would be, when circulated, would pass through passages that had had oil in them, and be subject to contamination by oil?

Mr. Conner: If you please, Mr. Lyon, I think that is a misstatement. Such a fact as you are talking about only happened at one well. I suggest you refer to the record of the testimony taken at Midland.

Mr. Lyon: I am cross-examining the witness to see what they told him.

Mr. Conner: Perfectly all right, but the question is incorrect as to the facts you are assuming.

Mr. Lyon: I am asking the witness. A. May I have the question, please?

(The pending question was read by the reporter.)

Mr. Wiles: If that is not the fact it is an entirely improper question. Counsel can't ask a question of that sort unless the facts are truly expressed. He can't use that kind of entrapment.

Mr. Lyon: That is my understanding of the fact. It doesn't make any difference. I don't think counsel has the

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right to get up and prompt the witness in answering the question.

Mr. Conner: We weren't prompting the witness here, Your Honor.

The Court: As I understand the question, it might be, and I don't know whether it is,—I wouldn't think he ought to ask a question unless it has already been proven or you have reason to think you will prove it.

Mr. Lyon: That is right.

The Court: You may not be able to. You might find something happens. But if you thought you were going to prove that, or if you claim it has been proven—

Mr. Lyon (Interposing): I understand that they admit it was true in one of these wells, and it was my information it is true in all of them. Maybe to a less degree.

The Court: Well—

Mr. Conner (interposing): Well, now, I would like to get it straight. The testimony is already in as to how these samples were taken. The opposite side was there and cross-examined. I think to Mr. Babcock's satisfaction it was determined when and where and how these samples were taken. They all came out of the manhole of the defendant's oil truck, and it is true in one case, which was the Crawford well, treated September 10, 1938, even though the acid came out of the manhole at the top part of the oil tank, it came out at a time after they had circulated the acid back from the tank through a valve and back into the tank again, which was their normal practice in this instance because they were mixing the acid with a substance called Klersol, which is not here in suit.

The Court: Would you have objection to it—because I am not sure I understand—if it was limited to that one sample?

Mr. Conner: If it is limited to the facts and correctly quotes the facts.

The Court: I mean—

Mr. Conner (interposing): Yes.

The Court: Not the rest.

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Mr. Conner: If he limits it to that one case.

The Court: It would seem to me it is all right. All he is asking him to do is to tell him that, and it would not be surprising to me if he didn't. I don't know anything about that.

Mr. Conner: I am probably just an old fuss-budget, but what I hate in this case is a loose use of the record.

The Court: Has that been proven in one case?

Mr. Conner: Yes.

The Court: I don't see it would be anything bad to ask if the witness was told that. I am not saying you can think of everything in the world that was told him; I don't see any objection to finding out whether he was told or not. I will let him answer that. We have had this discussion.

Mr. Lyon: I would like to ask this be pointed out in the record. The reason I didn't limit my question to the one well was because their witness Shelley, whose deposition is in the record, gave this testimony, page 94 of his deposition—

“Q. Did you look into the tank? A. I think so, yes.

“Q. But you don't remember whether there was any oil on the surface of the acid or on the walls of the tank? A. Well, I just can't be absolutely sure about it. I just didn't have that in mind at the time. There probably was skim oil on it. You can hardly find a tank there isn't skim oil on it.”

The Court: I will let him answer the question.

Mr. Lyon: Did Mr. Conner tell you anything about that subject at all or any of the other representatives of the Dow Company? A. As I remember at the time the samples were given to me no one mentioned the fact.

Q. Did they later? A. I learned later and I don't remember at the moment how, that that particular sample had received a treatment or processing which was different than that reported for the other samples. I did know that that sample was different but not at the time I got the samples.

Q. Well, you knew that the difference was in the fact

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that there was a substantial amount of oil in the sample?

A. I noticed that, yes.

Q. And are you prepared to state that there was no oil at all in other samples? A. No, I am not prepared to state that there was no oil.

Q. Did you make any test to determine whether or not, and if so in what quantity, the presence of oil would have any inhibiting effect on the acid? A. I don't recall that we have such data. We may have made some preliminary tests but I am not certain. We have not carried through any series of tests.

Mr. Lyon: Would it be all right to ask Dr. Cardwell if he knows there were any tests of that kind made?

Dr. Cardwell: I believe we did make some preliminary tests with oil.

Mr. Lyon: Well, I would like to know about those tests, what tests you made and what they showed. A. Well, we did not carry through on any of those tests because we were sufficiently occupied with the tests that we had under way.

Q. I would like to know what tests you did make on that subject and what the results were. As I understand from Dr. Cardwell there were some tests. Can you tell us what they were or refer to your records and tell us what they were? A. If I may see if I have anything in the record on that. (Witness conferred with Dr. Cardwell.) Some preliminary experiments were made using some of the oil that came on the sample that we have just referred to. Only a few preliminary tests were made.

May I have all of the question that was asked?

(Whereupon the question was read to the witness.)

A. Well, the results were of about this order. We did get an evidence of inhibition and the figures would be somewhere around 20 to 30% as the result of the use of that oil in the solution with the metal strips carried out just as we have described for the other experiments.

Q. Have you got your record or table on those tests here, either you or Dr. Cardwell? Can you produce the

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data on those tests? A. I am sure they are not here. They were just preliminary experiments.

Q. Can you also send those to me along with this other item that I asked for? A. I will be glad to.

Q. I notice in these exhibits that you have produced here, these various tables refer to Series D, Series A, Series C, and so forth. I do not think that has been explained. I would like to have you tell us how many series there were in your tests which have these different letters from A to what? And tell us in each case what the particular series consists of? A. As referring to the metal? Q. Yes, I guess they refer to metal. On table VII, I see metal strips of strap iron, Series D; and in others you refer to Series C and Series A? A. Yes.

Q. I want to know how those series work out. A. The series would indicate batches of strap iron that were made up. If, for example, a certain number of pieces were to be cut from a given lot of strap iron, that batch would be referred to, for example, as Series A; and if some other batch of strap iron were used, that batch would be referred to as Series B; and another batch of strap iron would be referred to as Series C and so on.

Q. How many letters did you have in that series? A. The tables will indicate that. They will indicate that, just about. I note that we have a series as low as L, and it is presumable that we had approximately that many batches of strap iron.

Q. Each one of these series are for a batch of strap iron, or do those include this National Supply pipe, and all of this— A. Those numbers refer to strap iron only.

Q. Well, now, you made tests with each one of those different series A to L? A. Yes, sir.

Q. Well, now, first I would like to have you tell me, identify, if you can, as to what series A was, what Series B was, and what tests were made with each series? A. Well, that would be shown in the tables.

Q. Which tables? A. Well, in table I, for example, two series of irons were used. Series D for the first—for the

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sample 8 Stella Wilcox, and sample 12-B from the Zala well, with corresponding things.

Q. I understand that, but I want to know what different tests you made with series A. Haven't you got a schedule which would show? A. I would have no such schedule. It would be readily available.

Q. Could you make me up a schedule which shows each one of these series and shows each one of the tests made with those series? Can you do that and compare the data which you brought in, and filling the spaces would seem incomplete, because I will want to check into that? I don't see any reports here on Series K or Series E or Series F, and I want to know, because you evidently had a complete program here, and we only have tables covering part of the data, and I want to find out what the rest of the data is? A. Well, the rest of the data, it might be that some of the sets might have been small sets used for preliminary experiments.

Q. Well, I want to find out. A. Yes.

Q. You understand? A. We will be glad to try to get you the information, if we have the record covering it.

Q. All right. A. I am not sure we have the record covering series A to L complete, but I will see.

Q. Will you give me as complete a record as you can? A. Yes.

Mr. Lyon: Now, I have agreed with Mr. Owen to make this statement, Your Honor. Prior to last Saturday I asked him to furnish me certain material, particularly over the adjournment, and he has furnished me certain material, and I would want to state on the record what he has furnished me, so the record will show whether it was a compliance.

He sent me a table of the experimental data which was obtained in the acid corrosion tests as presented in and described in Table XIX, PX-167.

He also sent me a table of the experimental data which was obtained in the acid corrosion test with samples numbered 1 and 2 on the Stella Wilcox well.

He also sent me a table of the data obtained in the acid

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corrosion test with the ~~arsenic~~ solutions prepared according to the disclosures on page 2, lines 74 to 78 of the Grebe and Sanford patent in suit.

And he also sent me a statement of the approximate dates on which the acid solution tests were made. I believe that is all you did send, Doctor. A. As I recall, and as I recall that was all that was requested.

Q. (By Mr. Lyon): I don't have in mind anything that you omitted? A. Yes.

Mr. Owen: Your Honor requested that a table be made showing the dates of purchase of commercial hydrochloric acid by the defendant and placed in its storage tanks at Mt. Pleasant, and of the different well treatments and taking of samples, and so forth, and I have prepared a chronological schedule here which will give you that information. I have given a copy of it to defendant's counsel.

The Court: That is what I want. Do you want to have that marked as an exhibit? It might be useful for somebody else. I am not asking it be done.

Mr. Owen: I think it might be marked as PX-172.

(The document above described was thereupon marked PX-172.)

REDIRECT EXAMINATION

Mr. Owen: Doctor, a considerable amount of cross examination referred to the percentages called for by the patent and included in those questions was one relating to what would be a relatively small amount of a corrosion inhibitor. In that connection I call your attention to a statement on page 1 of the patent, beginning in line 84, as follows: "The amount of arsenic compound added may be varied, but we have found that from 1 to 5 per cent thereof, based upon the weight of the solution will be satisfactory for the purpose." In view of that statement I will ask you what you understand the term relatively small amount to mean, that is, relative to what? A. Relative to the weight of the solution, strictly speaking.

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Q. I will ask you if the amounts of lead, copper and iron you found in the defendant's solutions were relatively small amounts with respect to the weight of the solutions?

A. They were.

Q. Now, how about the amounts of acridine, aniline, pyridine and quinoline, which you stated you had tested, being in some instances 1 per cent, and in other instances 3 per cent, and in other instances 5 per cent; do those refer to the percentages of the weights of the total solutions? A. That is right.

Q. In connection with your testimony regarding the testing of a 15 per cent hydrochloric acid solution containing 1 per cent of aniline—which you stated gave a 34 per cent reduction in corrosiveness—that is correct, is it not?

A. That figure is correct.

Q. Now, will you tell the court how much more corrosive that solution containing 1 per cent of aniline was than the defendant's solutions which you have stated were 47 per cent inhibited; that is, how many times more corrosive, I will ask you, was the solution containing 1 per cent of aniline, than the defendant's solution, which gave 47 per cent reduction in corrosiveness? A. Why, in the ratio of 66 to 53; that is to say, the solution containing the 1 per cent solution of aniline had a corrosiveness of 66, in relation to the defendant's acid, which would have a corrosive value of 53, so that would be the ratio of the corrosiveness.

Q. How many or how much is that in times, one and a half, one and three-quarters, one and a quarter, or what?

The Court: Which one to the other?

Q. I want to know how many times more corrosive the aniline solution was than the defendant's solution. A. A little less than one and a quarter.

Q. Now, would you consider that solution which you made containing one per cent of aniline to be within the disclosure of the Grebe-Sanford patent? A. I believe it is.

Q. How many times as corrosive was that one per cent aniline solution as was the solution which was made up in accordance with the patent example, and which you stated was 97 per cent inhibited? A. If my figures are right, in

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the neighborhood of the ratio of 66 to 3, or the corrosiveness of the one per cent aniline solution was about 22 times that of the arsenic solution referred to in the patent.

Q. Well, referring now to the solution you made up using acridine, and which I believe you stated reduced the corrosiveness of the acid 41 per cent, what would be the relative corrosiveness of that solution as compared with the defendant's solutions, taking them to be 47 per cent inhibited? A. The corrosiveness would be the ratio of 59 to 53. In other words, the corrosiveness of the acridine solution would be a little greater than that of the other solution referred to.

Q. Now, you stated, I believe, that that acridine solution was a saturated solution? A. That is right.

Q. By that, I understand that it took up all the acridine that the acid would dissolve? A. Yes; that is right.

Q. So that using that particular inhibitor, am I correct in stating that you could not get more than 41 per cent inhibition, according to your test? A. With our tests as conducted, at the temperature, constant temperature and all, one wouldn't expect to get much more reduction in corrosiveness with more acridine. It would not be in true solution, unless the suspended acridine might deposit on the plate, why, that would be the limiting value.

Mr. Lyon: I don't think the record shows what per cent of acridine went into solution in that test. May I ask? A. I recall we tried to make a one per cent solution, and it didn't quite all dissolve, so the answer would be the solution was somewhat less than one per cent.

Q. Mr. Owen: And I believe you have testified that the specific patent example using arsenic as the inhibitor contained only four-tenths of one per cent arsenic? A. Yes; this is right.

Q. Now, referring to your test using 1% of pyridine, your figure in that connection was 47% reduction in corrosiveness, as I recall. A. That is right.

Q. That is the same in that respect as the figure which

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we have been taking for the reduction in corrosiveness of the defendant's sample, is it not? A. Yes, it happens to be of the same value.

Mr. Owen: I will state in this connection, Your Honor, I am adopting the 47% counsel for defendant used, not with the intention of being limited to that, because some of the tests show a much higher reduction.

Q. Then your solution containing 1% of pyridine would bear the same relation in rate of corrosiveness to the patent example using arsenic as the defendant's acids bear to the patent example? A. That is right.

Q. Now, taking up your test in which you used 3% of aniline and secured a 60% reduction in corrosiveness, how much more corrosive is the defendant's acid based on the 47% figure than the solution containing the 3% of aniline? A. The ratio would be as 53 is to 40 or the defendant's acid would be about 1.3% more corrosive.

Q. You stated that the defendant's acid at 47% reduction in corrosiveness would be about 1.3% more corrosive than the 3% solution of aniline, is that correct? A. That is right. The ratio would be as 53 is to 40, or about 1.3.

Q. Stating it another way, the 3% aniline solution would be about three-fourths as corrosive as the defendant's acid, or .7? A. Approximately so, yes.

Q. And how much more corrosive was that 3% aniline solution than the solution you made up in accordance with the patent example using arsenic? A. The arsenic gave a corrosiveness which could be expressed as 3% against this 3% solution of aniline, having a corrosiveness of 40%, so the ratio of the corrosiveness effect would be as 3 is to 40.

Q. Or the aniline solution would be about 13 times as corrosive as the arsenic solution, is that correct? A. That is right.

Q. Then your 5 per cent pyridine solution gave 65 per cent reduction in corrosiveness, and your 5 per cent aniline solution 67 per cent reduction in corrosiveness? A. That is right.

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Q. Without asking you to make those computations I will simply ask if those two solutions were not still less corrosive than the defendant's solutions, that is, less in comparison with the ones I have previously referred to—well, that is a pretty complicated question.

The Court: It is 33. It is less than 40 and less than 66.

Mr. Owen: Yes.

Q. Then I will pass on down to the quinoline solutions. You made up three quinoline solutions, one containing 1 per cent of quinoline, one 3 per cent and one 5 per cent? A. That is right.

Q. And according to my figures each one of those gave 84 per cent reduction in corrosiveness? A. That is right.

Q. Now, how many times more corrosive were the defendant's acids than these quinoline solutions? A. About 3.3 times as corrosive.

Q. And how much more corrosive were the quinoline solutions than were the patent example solutions using arsenic? A. Approximately five times.

Q. So that here you have these quinoline examples five times as corrosive as the arsenic example of the patent, and still considerably less corrosive than the defendant's samples? A. That is true, assuming the defendant's sample has a reduction in corrosiveness of 47 per cent.

Mr. Owen: Now, the only other exhibits I want to offer are two sets of tables that Dr. Bartell furnished to Mr. Lyon, at his request, and I would like to offer this set in connection with the copy of Dr. Bartell's letter to Mr. Lyon dated August 4th, which states:

"Acting upon your request I am sending you herewith the experimental data which was obtained in our acid corrosion tests with samples numbered 1 and 2 from the Stella Wilcox well." I will offer that carbon copy of the letter and the four sheets of data as PX-247.

(Whereupon the document above referred was marked PX-247 by the reporter.)

Mr. Owen: I offer as PX-248 carbon copy of the letter written by Dr. Bartell to Mr. Lyon August 4th, reading as follows:

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"Acting upon your request I am sending you herewith the experimental data which was obtained in our acid corrosion tests as presented in and described in our Table XIX (PX-167)," and attached to that copy are three sheets of data.

(Whereupon the document above referred to was marked PX-248 by the Reporter.)

Mr. Owen: Doctor, have you recently made corrosion tests on a number of commercial acids? A. Yes, we have.

Q. Where did you obtain the acids? A. The acids were obtained from the Dow Chemical Company.

Mr. Owen: I will state for the record, Mr. Lyon, that these samples were either telegraphed for, or written for, by Mr. Crawford. Mr. Crawford either personally, or someone under his direction, wrote or wired to these various chemical companies, asking them to send one and two gallon samples of their commercial hydrochloric acid, and as those samples came into the Dow Chemical Company, they were sent down to Dr. Bartell, without being opened. That is the way they came to you, is that right, doctor? A. Yes.

Q. And you opened them and made tests of them? A. Yes.

Q. Now, will you state what samples you received and tested, and the results of the tests.

Mr. Lyon: Hasn't he got that all in a table here? Isn't that all tabulated here? Can't you offer this paper without him reading it?

Q. Mr. Owen: Have you a table showing the names of the companies from whom these samples were received, and the results of your tests? A. Yes, I have.

The table was offered and received as PX-358.

Q. Well, now, state, doctor, how you made these tests, that is what technique you followed? A. These tests were made in exactly the same manner that we had previously adopted as standard tests for making our acid corrosion tests. The metal used was strap iron cut to the size of one inch by one-eighth by three-sixteenths. The solutions were

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not agitated. The experiments were carried out at 85 degrees Fahrenheit. The volume of the acid solution on test was 50 c.c., the same as before, and the time of the test was 16 hours. It will be noted that two series of strap iron were used. That was because in preparing strap iron for tests a limited number of pieces are available from any one series of strap iron and we made use of two series.

CROSS EXAMINATION

By Mr. Lyon: Q. Doctor, referring to these tests that you have listed on PX-358 produced today, these various tests on the corrosiveness of these samples of commercial hydrochloric acid, when were these made? A. The acids were obtained on the 26th of August and the tests have been made since that time. Within the last two weeks.

Q. And did you make an analysis of these various commercial hydrochloric acids referred to on this exhibit 358 to determine their copper, iron and lead content? A. No, we did not.

Q. Or either of those three metals? A. No.